TMDLS FOR MERCURY IN FISH TISSUE FOR COASTAL BAYS AND GULF WATERS OF LOUISIANA

SUBSEGMENTS 010901, 021102, 042209, 070601, 110701, 120806

TMDL REPORT

Prepared for:

U.S. ENVIRONMENTAL PROTECTION AGENCY, REGION 6, DALLAS, TX
and the Office of Environmental Assessment
Louisiana Department of Environmental Quality
Contract 68-C-02-111

Prepared by:

Parsons

June 2005

TMDLS FOR MERCURY IN FISH TISSUE FOR COASTAL BAYS AND GULF WATERS OF LOUISIANA

SUBSEGMENTS

010901, 021102, 042209, 070601, 110701, 120806

TMDL REPORT

Prepared for

U.S. ENVIRONMENTAL PROTECTION AGENCY, REGION 6, DALLAS, TX

and the

Louisiana Department of Environmental Quality
Office of Environmental Assessment
Contract 68-C-02-111, Task Order 0007

Prepared by

Parsons
8000 Centre Park Dr., Suite 200
Austin, Texas 78754

JUNE 2005

EXECUTIVE SUMMARY

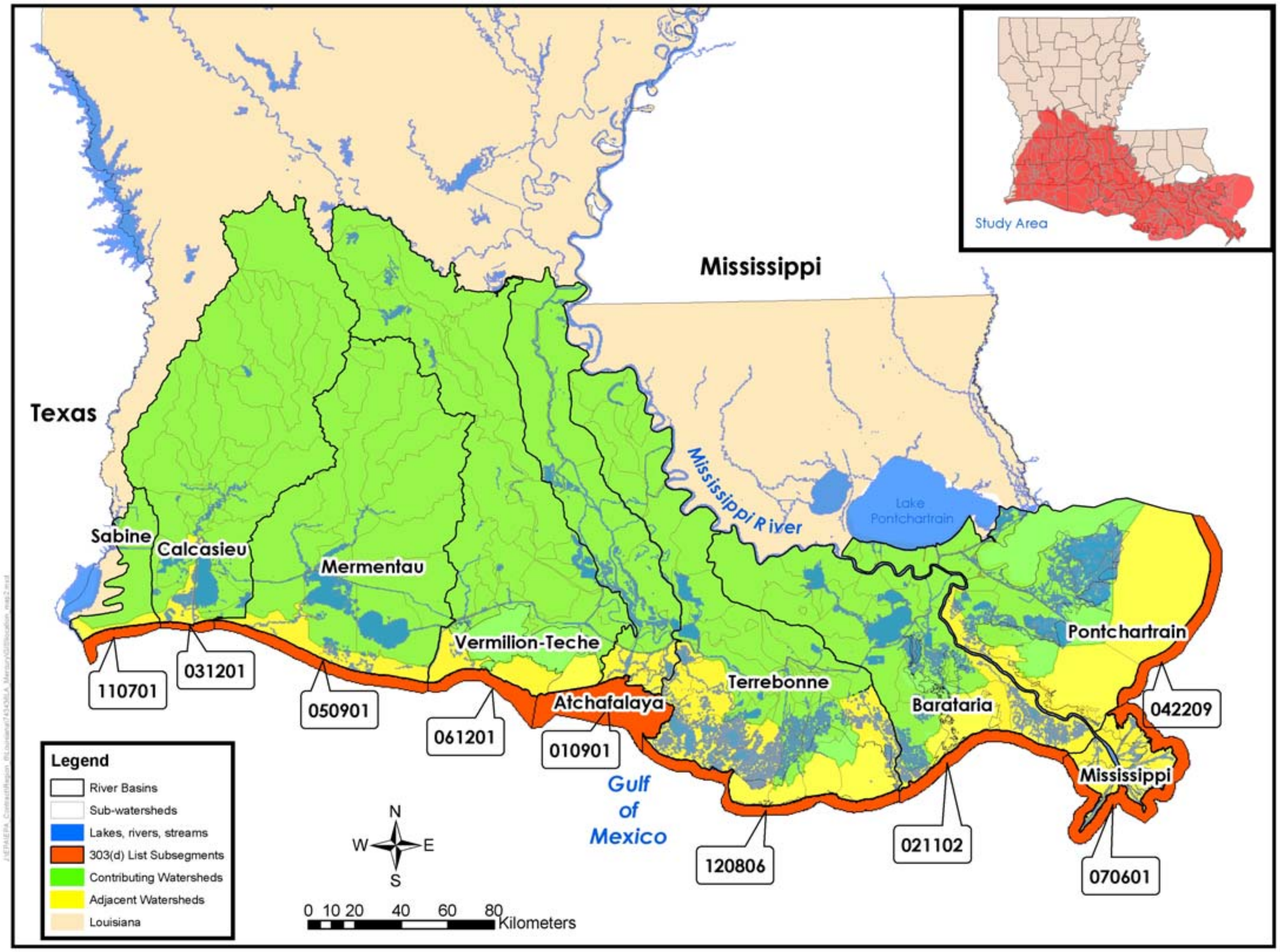
This report documents the data and assessment utilized to establish total maximum daily loads (TMDLs) for mercury (Hg) for six coastal waterbodies in Louisiana in accordance with requirements of Section 303 of the Clean Water Act (CWA), Water Quality Planning and Management Regulations (40 CFR Part 130), and U.S. Environmental Protection Agency (USEPA) guidance. The purpose of a TMDL is to determine the pollutant loading a waterbody can assimilate without exceeding the water quality standard for that pollutant. The TMDL also establishes the pollutant load allocation necessary to meet the water quality standard (WQS) established for each waterbody based on the relationship between pollutant sources and in-stream water quality conditions. The TMDL consists of a wasteload allocation (WLA), a load allocation (LA), and a margin of safety (MOS). The WLA is the fraction of the total pollutant load apportioned to point sources. The LA is the fraction of the total pollutant load apportioned to nonpoint sources. The MOS is a percentage of the TMDL that accounts for the uncertainty associated with the model assumptions and data inadequacies.

This TMDL meets the provisions of the federal CWA Section 303(d), which requires the Louisiana Department of Environmental Quality (LDEQ) or the USEPA to develop a pollutant load allocation for each waterbody/pollutant combination in response to a court order (Consent Decree) in the lawsuit styled Sierra Club, *et al.* v. Clifford, *et al.*, No. 96-0527, (E.D. La.) signed on April 1, 2002. The list established in the Consent Decree and later modified by LDEQ included mercury (Hg) in king mackerel fish tissue as a pollutant of concern in subsegments 010901, 021102, 031201, 042209, 050901, 061201, 070601, 110701, and 120806. USEPA has previously established Hg TMDLs for subsegment 031201 on May 28, 2002, and for subsegments 050901, and 061201 on January 19, 2001. USEPA proposed draft TMDLs for subsegments 010901, 021102, 042209, 070601, 110701, and 120806 on April 14, 2005. This final report contains EPA's responses to comments received on the draft TMDLs and establishes final Hg TMDLs for subsegments 010901, 021102, 042209, 070601, 110701, and 120806.

A fish consumption advisory for king mackerel (*Scomberomorus cavalla*) in the Gulf of Mexico off the coast of Louisiana was jointly issued by the Louisiana Department of Health and Hospitals (LDHH), the LDEQ, and the Louisiana Department of Wildlife and Fisheries (LDWF) due to elevated levels of Hg in king mackerel. The king mackerel fish consumption advisory for Coastal Bays and Gulf Waters of Louisiana extends along the entire 397 miles of coastline and covers approximately 1,191 square miles of coastal waters as shown in Figure ES-1.

Given the ubiquitous distribution of Hg and the large geographic area considered in this assessment, a watershed approach was used to develop the TMDLs summarized in this report. To adequately address Hg sources potentially contributing to the fish consumption advisory for king mackerel, this TMDL report evaluates subsegments that are hydrologically connected to

Figure ES.1 TMDL Study Area



the Coastal Bays and Gulf Waters of Louisiana including adjacent watersheds and contributing watersheds (see Figure ES-1). This TMDL report identifies point source discharges of Hg to the contributing and adjacent watersheds and estimates Hg loads from the Mississippi River Basin. This TMDL report also calculates nonpoint source Hg loads from atmospheric deposition for the entire study area and identifies Hg load reductions necessary to achieve applicable endpoints for the six subsegments for which Hg TMDLs are being established.

Nonpoint Source Load Estimate

Information to estimate the nonpoint source load for the coastal subsegments addressed by this TMDL includes water column and suspended solids data for the Mississippi River and air modeling to predict wet and dry mercury deposition.

The Mississippi River represents a significant source of Hg to the Coastal Bays and Gulf Waters of Louisiana because of the large drainage area and massive flow rate. The mercury load from the Mississippi River is the sum of the dissolved mercury in the water column and the total mercury on suspended solids. The Hg load is estimated by assuming that the mercury concentration of the total suspended solids is in equilibrium with the river bottom sediments. The total mercury load from the Mississippi River is estimated at 2,117,000 grams per year. Classification of Hg loading from the Mississippi River as a nonpoint source is necessary since it was beyond the scope of these TMDLs to differentiate point sources from nonpoint sources of mercury for a geographic area covering almost two-thirds of the continental United States.

It is a well known fact that a major source of nonpoint source loads of mercury in the environment are from air emissions. The USEPA used an air model to estimate nonpoint source loads. The model used was REMSAD, Version 7 (USEPA 2004). A report detailing the approach and outputs of REMSAD for the Louisiana coast entitled *REMSAD Air Deposition Modeling in Support of TMDL Development for Southern Louisiana* was finalized by USEPA Region 6 in August 2004.

Output from the REMSAD model was used as input to the Pollutant Load (PLOAD) application of the BASINS Version 3 model to estimate nonpoint source Hg loads on an annual average basis. USEPA chose to base its calculations of nonpoint source mercury loading to the 303(d) listed subsegments on the conservative assumption that 100 percent of the nonpoint source loads are transported to the coastal basins. This assumption was made to calculate the mercury load transported to the receiving waters from runoff in both the adjacent watersheds and the upstream contributing watersheds and to estimate the Hg loadings associated with sediments eroded from each watershed.

Point Source Load Estimate

Information on National Pollutant Discharge Elimination System (NPDES) permitted dischargers was obtained from the USEPA Permits Compliance System (PCS) database. PCS indicated that there are over 600 dischargers in the study area of which only five point source dischargers currently have mercury limitations in their NPDES permits for the six segments for which new TMDLs are being established.

Because effluent sampling for mercury in the past has been conducted without the benefit of newer clean techniques, little is known about the potential to discharge mercury for the majority of dischargers. The approach utilized to estimate point source loads includes considering point source wasteloads based on mercury limits in existing permits, an assumption of 12 ng/L mercury in the discharge of WWTPs with flows greater than 100,000 gpd, and an unassigned wasteload has been included for each TMDL. USEPA believes it is appropriate to assume that discharges from the municipal WWTPs (SIC 4952) discharging greater than 100,000 gpd in these watersheds contain mercury levels equal to 12.0 ng/L.

Estimated Current Loading

The following table summarizes the current estimated Hg loading from point sources and nonpoint sources.

Table ES.1 Summary of Estimated Current Mercury Loading

Coastal Segment	Segment Name	Point Source Hg Load (g/yr)	Point Source Basin Load %	Total Mercury Nonpoint Source Hg Load (g/yr)	Nonpoint Source Basin Load %	Total Hg Load (g/yr)
010901	Atchafalaya Bay and Delta	174	0.3	55,629	99.7	55,803
021102	Barataria Basin Coastal Bays	324	0.3	94,590	99.7	94,914
042209	Lake Pontchartrain Basin Coastal Bays	527	1.0	52,188	99.0	52,715
070601	Mississippi River Basin Coastal Bays*	0	0.0	2,127,578	100.0	2,127,578
110701	Sabine River Basin Coastal Bays	57	0.3	20,077	99.7	20,134
120806	Terrebonne River Basin Coastal Bays	985	0.8	115,321	99.2	116,306

Endpoint Identification

In Louisiana, when the average Hg concentration exceeds 0.5 parts per million (mg/kg) in fish or shellfish, a fish consumption advisory may be issued. The concentration of Hg in king mackerel exceeds 1.0 mg/kg in numerous locations in Gulf Waters along the Louisiana coast; therefore, a precautionary fish consumption advisory for the area was issued by the LDEQ, LDHH, and LDWF. EPA has chosen to use an average Hg concentration of 0.5 parts per million (mg/kg) in king mackerel as the endpoint for these TMDLs.

The average concentration for Hg for all king mackerel collected off the coast of Louisiana is 1.2129 mg/kg as shown in the following table.

Table ES.2 Mercury in King Mackerel Tissue (mg/kg)

Min	Avg	Max	n
0.1334	1.2129	5.9040	74

The mercury concentration in fish tissue must be reduced by 59 percent to achieve the safe tissue concentration of 0.5 mg/kg. Therefore, the mercury load to the watershed must also be reduced by 59 percent based on the assumption that there is a linear relationship between the mercury load and mercury concentration in fish tissue.

Percent Reduction = [(1.2129 mg/kg - 0.50 mg/kg) / (1.2129 mg/kg)] X 100 = 59%

Since the majority of Hg in the environment is from air emission and most mercury reductions will be achieved through Clean Air Act regulations, USEPA is not requiring point source dischargers to make any reductions at this time. The required load reductions are expected to come from nonpoint sources and are shown in the following table.

Table ES.3 Load Allocations for Coastal Basins

Coastal Segment	Segment Name	Point Source Hg Load (g/yr)	NPS Hg Load (g/yr)	Total Hg Load (g/yr)	Hg Load Reduction (g/yr)	NPS Load Allocation (g/yr)
010901	Atchafalaya Bay and Delta	174	55,629	55,803	32,924	22,705
021102	Barataria Basin Coastal Bays	324	94,590	94,914	56,000	38,591
042209	Lake Pontchartrain Basin Coastal Bays	527	52,188	52,715	31,102	21,086
070601	Mississippi River Basin Coastal Bays	0	2,127,578	2,127,578	1,255,271	872,307
110701	Sabine River Basin Coastal Bays	57	20,077	20,134	11,879	8,198
120806	Terrebonne River Basin Coastal Bays	985	115,321	116,306	68,620	46,700

NPS Non Point Source

TMDLs

The TMDLs outlined in the following table provide the WLA (point sources), LA (nonpoint sources), and MOS (implicit) as required for each 303(d)-listed coastal subsegment.

Table ES.4 TMDL Summary

Coastal Segment	Segment Name	TMDL (g/yr)	WLA (g/yr)	LA (g/yr)	MOS (g/yr)
010901	Atchafalaya Bay and Delta	22,879	**174**	**22,705**	**0**
021102	Barataria Basin Coastal Bays	38,915	**324**	**38,591**	**0**
042209	Lake Pontchartrain Basin Coastal Bays	21,613	**527**	**21,086**	**0**
070601	Mississippi River Basin Coastal Bays	872,307	*****	**872,307**	**0**
110701	Sabine River Basin Coastal Bays	8,255	**57**	**8,198**	**0**
120806	Terrebonne River Basin Coastal Bays	47,685	**985**	**46,700**	**0**

* EPA notes that the load allocation for the Mississippi River basin accounts for the mercury load from upstream sources in the basin (including point and nonpoint sources). Because of the large geographic scope of the basin and the difficulty in identifying specific sources, EPA has not allocated specific waste loads to point sources in the Mississippi River basin upstream of the TMDL area. However, EPA understands that Louisiana will issue NPDES permits for sources in the upstream area within the State's jurisdiction, and in doing so will evaluate whether the point source discharge will cause or contribute to a localized exceedance of the applicable water quality standard and determine the appropriate permit limit accordingly. Thus, the inability to identify and assign specific WLAs to sources in areas outside the basins subject to the TMDL does not mean that such sources will be unable to obtain NPDES permits.

Pollutant Load Reductions

This TMDL report indicates that current Hg loadings throughout the project study area are primarily from nonpoint sources. A 59 percent reduction in Hg loading is necessary to achieve the applicable endpoint of 0.5 mg/kg in fish tissue. Consequently, significant reductions in atmospheric deposition within and outside the study area will be necessary. EPA expects that a combination of ongoing and future activities under the Clean Air Act will achieve reductions in air deposition of mercury that will enable progress towards achievement of water quality standards.

USEPA recognizes that it may be appropriate to revise these TMDLs at some point in the future based on new information gathered and analyses performed. An adaptive management approach allows USEPA or the State to use the best information available at the time to establish the TMDL at levels necessary to implement applicable WQSs and to make the allocations to the pollution sources. EPA recognizes that additional data and information may be necessary to validate the assumptions of the TMDL and to provide greater certainty that the TMDL will achieve the applicable water quality standard (WQS). The adaptive management approach is appropriate for these TMDLs because information on the actual contributions of Hg from both point and nonpoint sources will be much better characterized in the future. USEPA expects point source loadings of Hg to be reduced primarily through Hg minimization programs developed and implemented by some point sources.

During implementation of these TMDLs, USEPA expects the following activities to occur:

- NPDES point source dischargers will develop and implement Hg minimization plans as appropriate.
- Air emissions of Hg will be reduced through implementation of the CAA regulation; and
- LDEQ will collect additional ambient data on Hg concentrations in water, sediment, fish, and soil; and
- LDEQ will develop and implement a mercury risk reduction plan that assesses all sources of mercury.

TABLE OF CONTENTS

APPENDICES

LIST OF FIGURES

LIST OF TABLES

ACRONYMS AND ABBREVIATIONS

μg/L	Micrograms per liter
AMSA	Association of Metropolitan Sewerage Agencies
BASINS	Better Assessment Science Integrating Point and Nonpoint Sources
CWA	Clean Water Act
DOC	Dissolved organic carbon
E-MCM	Everglades Mercury Cycle Model
EPCRA	Emergency Planning and Community Right-to-Know Act
FDA	Food and Drug Administration
g/yr	Grams per year
GIS	Geographic information system
GIWW	Gulf Intracoastal Waterway
gpd	Gallons per day
Hg	Mercury
HNC	Houma Navigation Canal
HWC	Hazardous waste combustors
IHNC	Inner Harbor Navigation Canal
kg/yr	Kilograms per year
km	Kilometer
LA	Load allocation
LAC	Louisiana Administrative Code
lbs/yr	Pounds per year
LDEQ	Louisiana Department of Environmental Quality
LDHH	Louisiana Department of Health and Hospitals
LDWF	Louisiana Department of Wildlife and Fisheries
LPDES	Louisiana Pollutant Discharge Elimination System
m	Meter
MACT	Maximum achievable control technology
MDN	Mercury Deposition Network
mg/kg	Milligram per kilogram
mgd	Million gallons per day
MOS	Margin of safety
MRGO	Mississippi River Gulf Outlet
MWC	Municipal waste combustors
MWI	Municipal waste incinerators
NADP	National Atmospheric Deposition Program
ng/L	Nanograms per liter
NPDES	National Pollutant Discharge Elimination System
PCS	USEPA Permit Compliance System
PLOAD	Pollutant load
POTW	Publicly owned treatment works

ppm	Parts per million
REMSAD	Regional Modeling System for Aerosols and Deposition
RGM	Reactive gaseous mercury
SIC	Standard industrial classification
STATSGO	State soil geographic database
TEDI	Toxics emissions data inventory
TMDL	Total maximum daily load
tpy	Tons per year
TRI	Toxic release inventory
TSS	Total suspended solids
USEPA	U.S. Environmental Protection Agency
USGS	United States Geological Survey
WLA	Wasteload allocation
WQS	Water quality standard
WWTP	Wastewater treatment plant

SECTION 1
INTRODUCTION

This report documents the data and assessment utilized to establish total maximum daily loads (TMDL) for mercury for six coastal waterbodies in Louisiana in accordance with requirements of §303 of the Clean Water Act (CWA), Water Quality Planning and Management Regulations (40 CFR Part 130), and U.S. Environmental Protection Agency (USEPA) guidance and the court order (Consent Decree) in the lawsuit styled Sierra Club, *et al.*, v. Clifford, *et al.*, No. 96-0527, (E.D.La.) signed on April 1, 2002. The purpose of a TMDL is to determine the pollutant loading a waterbody can assimilate without exceeding the water quality standard for that pollutant. The TMDL also establishes the pollutant load allocation necessary to meet the water quality standard (WQS) established for each waterbody based on the relationship between pollutant sources and in-stream water quality conditions. The TMDL consists of a wasteload allocation (WLA), a load allocation (LA), and a margin of safety (MOS). The WLA is the fraction of the total pollutant load apportioned to point sources. The LA is the fraction of the total pollutant load apportioned to nonpoint sources. The MOS is a percentage of the TMDL that accounts for the uncertainty associated with the model assumptions and data inadequacies.

A fish consumption advisory for king mackerel (*Scomberomorus cavalla*) in the Gulf of Mexico off the coast of Louisiana was jointly issued by the Louisiana Department of Health and Hospitals (LDHH), the Louisiana Department of Environmental Quality (LDEQ), and the Louisiana Department of Wildlife and Fisheries (LDWF) on August 4, 1997 due to elevated levels of mercury (Hg) in king mackerel. The concentration of mercury in fish tissue for king mackerel collected off the coast of Louisiana from 1996 to 2004 is shown in Figure 1.1. The Consent Decree required the establishment of TMDLs to address the fish consumption advisory. EPA has previously established TMDLs for subsegments 050901 and 061201 in January 2001 and subsegment 031201 in May 2002. EPA is establishing TMDLs for the remaining six coastal subsegments in this TMDL report. King mackerel is one of six species with the greatest average annual recreational fisheries landings in pounds from the Gulf of Mexico (Ache, *et al.* 2000). The annual average landings of king mackerel based on data from 1995 through 1997 were 5,270,745 pounds (NOAA 1999). King mackerel, a pelagic fish, range throughout the northern Gulf of Mexico, migrating along the northern coast from the Florida Keys to Texas. Given the ubiquitous distribution of Hg and the large geographic area considered in this assessment, a watershed rather than a waterbody-specific approach was used to develop the TMDLs summarized in this report. To adequately address Hg sources potentially contributing to the fish consumption advisory for king mackerel, this TMDL report evaluates subsegments that are hydrologically connected to the Coastal Bays and Gulf Waters of Louisiana.

The purpose of this TMDL report is to establish the acceptable loading of mercury from all sources so that mercury levels in fish tissue will decline and compliance with the narrative WQS will be achieved. This TMDL report identifies point source discharges of mercury to the contributing and adjacent watersheds, estimates mercury loads from the Mississippi River

Basin as nonpoint source contributions to the Gulf of Mexico, and calculates nonpoint source mercury loads from atmospheric deposition.

Figure 1.2 shows the 303(d)-listed subsegments along the Louisiana coast. Table 1.1 lists the Coastal Bays and Gulf Waters of Louisiana included in the fish consumption advisory, which are on the State 303(d) list and addressed in this TMDL report.

Figure 1.1 Mercury Concentration in King Mackerel Tissue

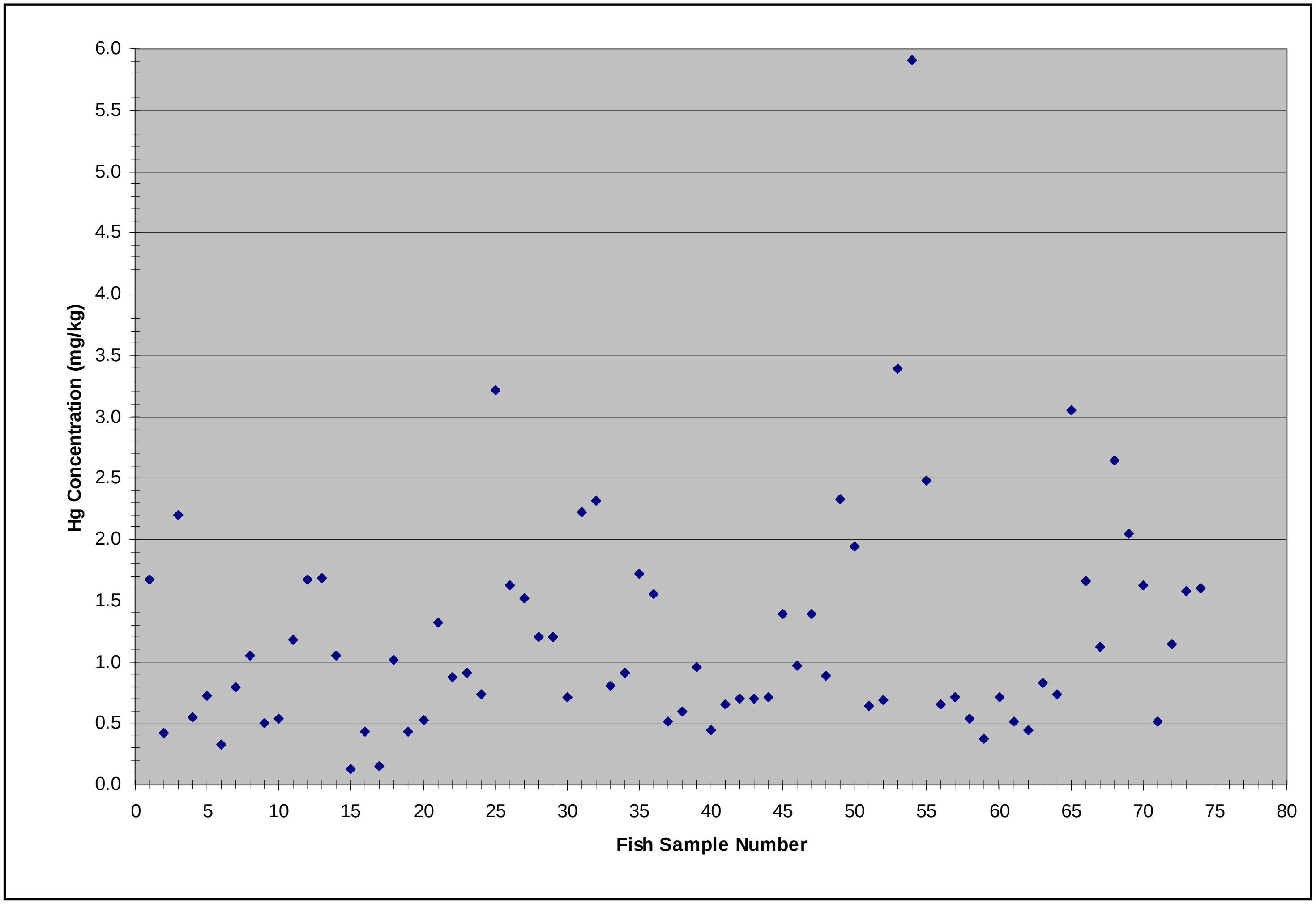


Figure 1.2 Fish Consumption Advisory Area – 303(d) Listed Subsegments

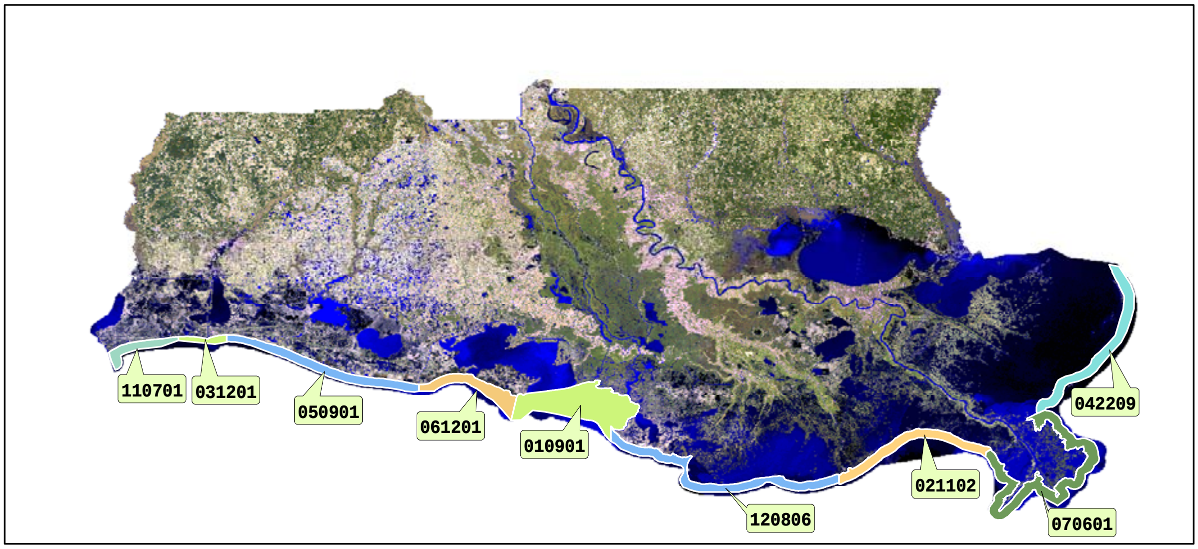


Table 1.1 Coastal Bays and Gulf Waters of Louisiana

LDEQ Subsegment	Description
010901	Atchafalaya Bay and Delta and Gulf Waters to the State 3-mile Limit
021102	Barataria Basin Coastal Bays and Gulf Waters to the State 3-mile Limit
031201	Calcasieu River Basin Coastal Bays and Gulf Waters to the State 3-mile Limit
042209	Lake Pontchartrain Basin Coastal Bays and Gulf Waters to the State 3-mile Limit
050901	Mermentau River Basin Coastal Bays and Gulf Waters to the State 3-mile Limit
061201	Vermilion-Teche River Basin Coastal Bays and Gulf Waters to the State 3-mile Limit
070601	Mississippi River Basin Coastal Bays and Gulf Waters to the State 3-mile Limit
110701	Sabine River Basin Coastal Bays and Gulf Waters to the State 3-mile Limit
120806	Terrebonne Basin Coastal Bays and Gulf Waters to the State 3-mile Limit

SECTION 2
APPROACH TO THE TMDLS

In general, the selection of a TMDL approach depends on the availability of data and information about the sources, fate, and transport of the pollutant to be controlled. The level of effort and scientific knowledge needed to acquire adequate data and perform meaningful predictive analysis is often a function of the pollutant source, pollutant characteristics, and the geographical scale of the pollution problem. Modeling the fate and transport of conventional pollutants (*e.g*., biological oxygen demand) and point source contributions is better developed than modeling the non-traditional pollution problems such as mercury. For non-traditional pollution problems, if there are not adequate data and predictive tools to characterize and analyze the pollution problem with a known level of uncertainty, an adaptive management approach is appropriate.

USEPA recognizes that it may be appropriate to revise these TMDLs based on information gathered and analyses performed after July 2005. An adaptive management approach allows USEPA or the state to use the best information available at the time to establish the TMDL at levels necessary to implement applicable WQSs and to make the allocations to the pollution sources. This approach recognizes that additional data and information may be necessary to validate the assumptions of the TMDL and to provide greater certainty that the TMDL will achieve the applicable WQS and allows for revision to the needed load reductions or the allocation of the allowable load, or both. USEPA, in conjunction with LDEQ, intends to gather new information and perform new analyses to revise these TMDLs for Hg, if necessary. This approach is appropriate for these TMDLs because information on the actual contributions of Hg from both point and nonpoint sources will be much better characterized in the future. (USEPA 2004b).

2.1 APPROACH TO ATMOSPHERIC SOURCES

The waterbodies covered by these TMDLs are impaired due largely to the deposition of Hg from the atmosphere. These TMDLs estimate that over 99 percent of the pollutant loads to the waterbodies come from the atmosphere. The Hg that reaches the watershed comes from nearby local sources as well as atmospheric sources much farther away, both within the United States (national sources) and outside of the United States (international sources). These TMDLs also estimates that only about one percent of the Hg loading is due to point source discharges.

USEPA previously attempted to characterize the air sources of Hg to surrounding watersheds using the Regional Model System for Aerosols and Deposition (REMSAD), as reported in the Mercury Study Report to Congress (USEPA 1997). The REMSAD model used for these TMDLs was enhanced to better account for the complex atmospheric chemistry of mercury. While uncertainties still exist, USEPA believes the assumptions made to address these uncertainties are reasonable and consistent with state-of-the art mercury modeling available at the time this TMDL was prepared. USEPA is not able at this time to estimate all the reductions in mercury deposition that will be achieved for future activities. However, as contemplated by Section 303(d)(1)(C), these TMDLS quantify the water quality problem and identify the loadings for atmospheric deposition that would need to be reduced by CAA initiatives or under other authorities to enable progress toward achieving applicable standards for mercury in the watersheds.

2.2 APPROACH TO WATER POINT SOURCES

At this time there is relatively little data on the actual loading of Hg from NPDES point sources in the coastal basins. Prior to 1998, USEPA's published method for the analysis of Hg was not sensitive enough to measure it at low trace level concentrations, and thus, most NPDES facilities did not detect Hg during their required priority pollutant monitoring. USEPA has now adopted Method 1631 for the analysis of Hg in water with a detection level of 0.5 nanograms per liter (ng/L) (67FR65876, October 29, 2002).

As targeted NPDES permits are reissued, some dischargers will be required to use the latest revision of Method 1631 for analyzing mercury. Therefore, data on the concentration of mercury in point source discharges will be available to characterize the actual loading of Hg. This will allow USEPA to refine WLAs in the future, if appropriate.

Since most of the needed Hg reductions will be achieved through Clean Air Act reductions in mercury emissions from air sources, USEPA expects point source loadings of Hg to be reduced primarily through Hg minimization programs developed and implemented by some point sources.

In summary USEPA expects the following activities to occur:

- NPDES point source dischargers will develop and implement Hg minimization plans as appropriate.
- Air emissions of Hg will be reduced through implementation of the Clean Air Act regulation; and
- LDEQ will collect additional ambient data on Hg concentrations in water, sediment, fish, and soil; and
- LDEQ will develop and implement a mercury risk reduction plan that assesses all sources of mercury.

USEPA intends to use the data and information collected to revise these TMDLs, as necessary in the future.

SECTION 3
STUDY AREA DESCRIPTION

Louisiana lies entirely in the Gulf Coastal Plain physiographic province and can be divided into five natural physiographic regions: Coastal Marsh, Mississippi Alluvial Valley, Red River Valley, Terraces, and Hills. The lowest elevations are found in the Coastal Marsh area, which extends across the southern portion of Louisiana and represents a valuable fisheries and wildlife resource (LDEQ 2004). The State of Louisiana Water Quality Management Plan and Water Quality Inventory Integrated Report (Section 305(b) and 303(d) Reports) indicate there are 397 miles of coastline, 7,656 square miles of bays and estuaries, over 2.5 million acres of tidal wetlands, and nearly 1.0 million acres of coastal swamp and freshwater marsh in Louisiana. The King mackerel fish consumption advisory for Coastal Bays and Gulf Waters of Louisiana extends along the entire 397 miles of coastline and covers approximately 1,191 square miles of coastal waters (LDEQ 2004c). Figure 3.1 is an aerial photograph of a typical Louisiana coastal area.

Figure 3.1 Typical Louisiana Coastal Area

USEPA elected to use a watershed rather than a waterbody-specific approach for developing the TMDLs in this report given the large geographic extent of the listed subsegments and the global, national, and regional source contributions of Hg in the environment. As a result, the assessment approach used to develop these TMDLs recognizes the importance of identifying mercury sources from the subsegments hydrologically linked to the Coastal Bays and Gulf Waters of Louisiana listed on the 303(d) list. Figure 3.2 shows the coastal basins along the Louisiana coast that define the boundary of the study area. These coastal basins encompass roughly the bottom third of the state. Each coastal basin can also be further divided into **adjacent watersheds** and **contributing watersheds** which are also displayed in Figure 3.2. Mercury loads are estimated for adjacent watersheds and contributing watersheds, and TMDLs are developed for six 303(d)-listed Coastal Bays and Gulf Waters of Louisiana.

At the outset of the development of these TMDLs, USEPA made the decision not to attempt to estimate background levels of Hg or model Hg cycling within the Gulf of Mexico. Another major aspect affecting the project study area is the role the Mississippi River Basin plays in the contribution of Hg loading to the Gulf of Mexico. USEPA estimates a dissolved mercury load and a particulate mercury load for the Mississippi River as discussed in Section 6. However, it is beyond the scope of this project to segregate and specify point and nonpoint sources of mercury loading from a geographic area that covers approximately two-thirds of the continental United States. Table 3.1 is a list of the parishes included within the study area of this project.

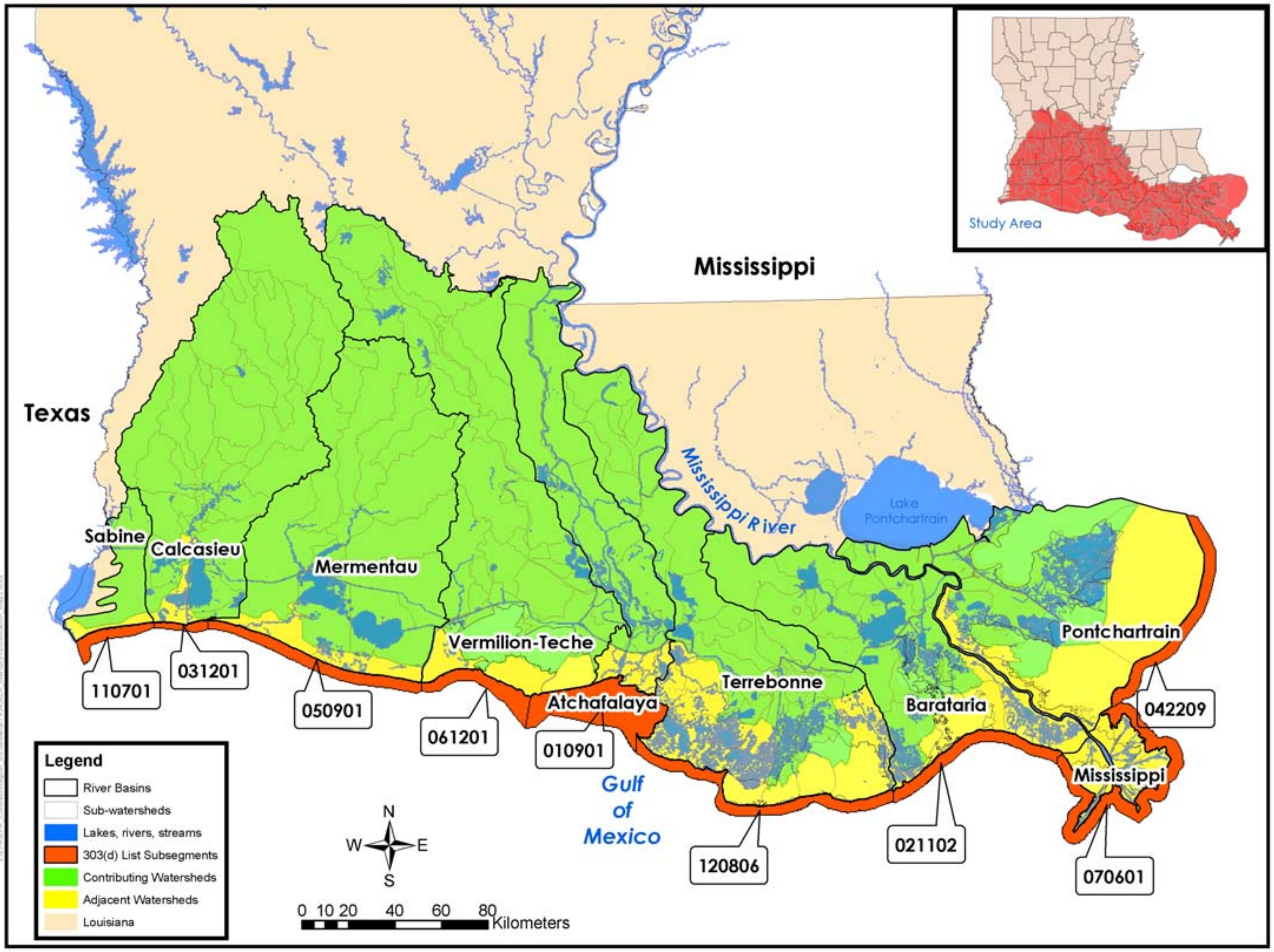
Table 3.1 Parishes in Study Area

CAMERON	ST. JOHN THE BAPTIST	VERMILION
Calcasieu	St. Charles	Iberia
Beauregard	Jefferson	St. Martin
Vernon	St. Bernard	St. Mary
Rapides	Allen	Terrebonne
Avoyelles	Jefferson Davis	Lafourche
Pointe Coupee	Evangeline	Plaquemines
Iberville	Acadia	Orleans
Assumption	St. Landry	West Baton Rouge
St. James	Lafayette	Concordia
Ascension		

3.1 RAINFALL

Louisiana has a humid subtropical climate influenced by the extensive landmass to the north, the Gulf of Mexico to the south, and the subtropical latitude. Prevailing winds from the south/southeast bring in warm, moist air from the Gulf of Mexico, resulting in abundant rainfall (LDEQ 2004). The annual rainfall in the study area ranges from 56-57 inches along the western part of Louisiana to 62-65 inches in the southeastern part of the study area. Figure 3.3 at the end of this section is a rainfall map of the southern portion of Louisiana.

Figure 3.2 TMDL Study Area



3.2 HYDROLOGY

All Louisiana coastal subsegments in the study area receive hydrologic inputs from the Gulf of Mexico with Gulf currents moving primarily in a westward direction along the Louisiana coastline. Freshwater and tidal flows are poorly understood along the Louisiana coast. Table 3.2 summarizes the primary hydrologic inputs to each coastal subsegment. The combination of the Gulf current, the multidirectional flow dynamics between freshwater delivered to the Coastal Bays and Gulf Waters, and the inland movement of marine water make hydrodynamic modeling for Hg cycling complex. USEPA is establishing Hg TMDLs for six of the subsegments listed in Table 3.2 (010901, 021102, 042209, 070601, 110701, and 120806). Mercury TMDLs have already been established for subsegments 031201, 050901 and 061201.

Table 3.2 Overview of Hydrologic Inputs to Louisiana Coastal Bays and Gulf Waters in the Study Area

LDEQ Subsegment	Description	Hydrologic Inputs*
010901	Atchafalaya Bay and Delta and Gulf Waters to the State 3-mile limit	Lower Atchafalaya River, Wax Lake Outlet, Atchafalaya Bay, and the Atchafalaya River and Bayous Chene, Boeuf, and Black navigation channel.
021102	Barataria Basin Coastal Bays and Gulf Waters to the State 3-mile limit	Limited freshwater inflows; diversions from the Mississippi River through Bayou Lafourche are restricted; rainfall runoff from Barataria Basin
031201	Calcasieu River Basin Coastal Bays and Gulf Waters to the State 3-mile limit	Calcasieu River, Calcasieu Lake, Calcasieu Ship Channel
042209	Lake Pontchartrain Basin Coastal Bays and Gulf Waters to the State 3-mile Limit (For the purposes of this assessment, this subsegment includes the Breton Sound Basin)	The Inner Harbor Navigation Canal (IHNC) and the Mississippi River Gulf Outlet (MRGO) provide a direct link between Lake Pontchartrain and the Gulf of Mexico. Historically, fresh water entered the Pontchartrain Basin through Bayou Manchac (until its closure in 1812) and from natural crevasses from the Mississippi River (until construction of the Mississippi River levees in the 1930s). Fresh water now enters the Pontchartrain Basin through leaks in the Bonnet Carré Spillway, through the IHNC Lock, the Violet Siphon, numerous small rivers and bayous (totaling approximately 9,500 cfs), and from direct rainfall. Urban storm water discharges from the New Orleans metropolitan area also enter Lake Pontchartrain. The principal hydrologic features of the Breton Sound Basin include the Mississippi River and its natural levee ridges; the MRGO south disposal bank; Bayou Terre aux Boeufs and River aux Chenes (abandoned delta distributaries); and the freshwater diversions at Caernarvon, Whiteis Ditch, Bohemia, and Bayou Lamoque. Historically, the basin was flushed with large quantities of fresh water and sediments annually during the spring. Marine waters would then rise and enter the basin during the late summer and early fall months and would be flushed out the following spring. The flood protection levees

LDEQ Subsegment	Description	Hydrologic Inputs*
		raised along the Mississippi River in the early 1930s as far south as Bohemia in the Breton Sound Basin prevented the annual input of fresh water, nutrients, and sediments.
050901	Mermentau River Basin Coastal Bays and Gulf Waters to the State 3-mile limit	Significant hydrological alterations minimize fresh water entering the subbasin through the Mermentau River, Lacassine Bayou, the Bell City Drainage Canal, the Gueydan Canal, the Warren Canal, and a number of other smaller drainage canals.
061201	Vermilion-Teche River Basin Coastal Bays and Gulf Waters to the State 3-mile limit	The principal hydrologic features of the Vermilion-Teche River Basin include the Vermilion River, Charenton Canal, the Gulf Intracoastal Waterway (GIWW), the natural levee ridges of the Vermilion River and Bayou Teche, East and West Cote Blanche Bays, and Vermilion Bay. Unlike other basins in the Chenier plain, the Vermilion-Teche Basin has direct riverine inputs. This basin is experiencing an increase in riverine flows because of sediment-laden freshwater flow from the Atchafalaya River. Water and sediment from the Atchafalaya River enter the basin from the east, flow westward, and dominate hydrological conditions in East and West Cote Blanche Bays.
070601	Mississippi River Basin Coastal Bays and Gulf Waters to the State 3-mile limit	The Mississippi River discharges the headwater flows from about 41 percent of the contiguous 48 states. On a long-term daily basis, discharges into the Mississippi River average 470,000 cfs. A peak discharge of approximately 1,250,000 cfs occurs on the average of once every 16 years downstream of New Orleans.
110701	Sabine River Basin Coastal Bays and Gulf Waters to the State 3-mile Limit	Sabine River
120806	Terrebonne Basin Coastal Bays and Gulf Waters to the State 3-mile Limit	Freshwater inflows are supplied to the northern and western areas of the Terrebonne Basin by the Atchafalaya River. The Timbalier Subbasin (in the basin's southeast region) gets fresh water from rainfall (65 inches/year) and from Atchafalaya River inflow to the GIWW via the Houma Navigation Canal (HNC) and Grand Bayou Canal.

*Source: Descriptions of Hydrologic Inputs from Louisiana's CWRPPA Basins - http://www.lacoast.gov/geography/index.htm

3.3 SOIL

As can be expected, soil types are numerous and varied because of the large project study area. Figure 3.4 is a soil map of the study area. Soil classifications are from the State Soil Geographic (STATSGO) database.

3.4 LAND USE

The study area covers approximately 14,265,000 acres of Louisiana. In 2000, over 2 million residents (more than 50 percent of the state's population according to U.S. Census estimates) lived in Louisiana's coastal parishes (U.S. Census Bureau 2002).

Land cover for the study area is shown in Figure 3.5. These land use figures were derived from the USEPA Better Assessment Science Integrating Point and Nonpoint Sources (BASINS) Version 3 datasets which rely on United States Geological Survey (USGS) land use/land cover data. Table 3.3 includes the land use area for each coastal basin. Nonforested wetlands (11.52%), forested wetlands (22.18%), and cropland and pasture (27.67%), are the three largest land use categories within the study area.

Figure 3.3 Rainfall Map

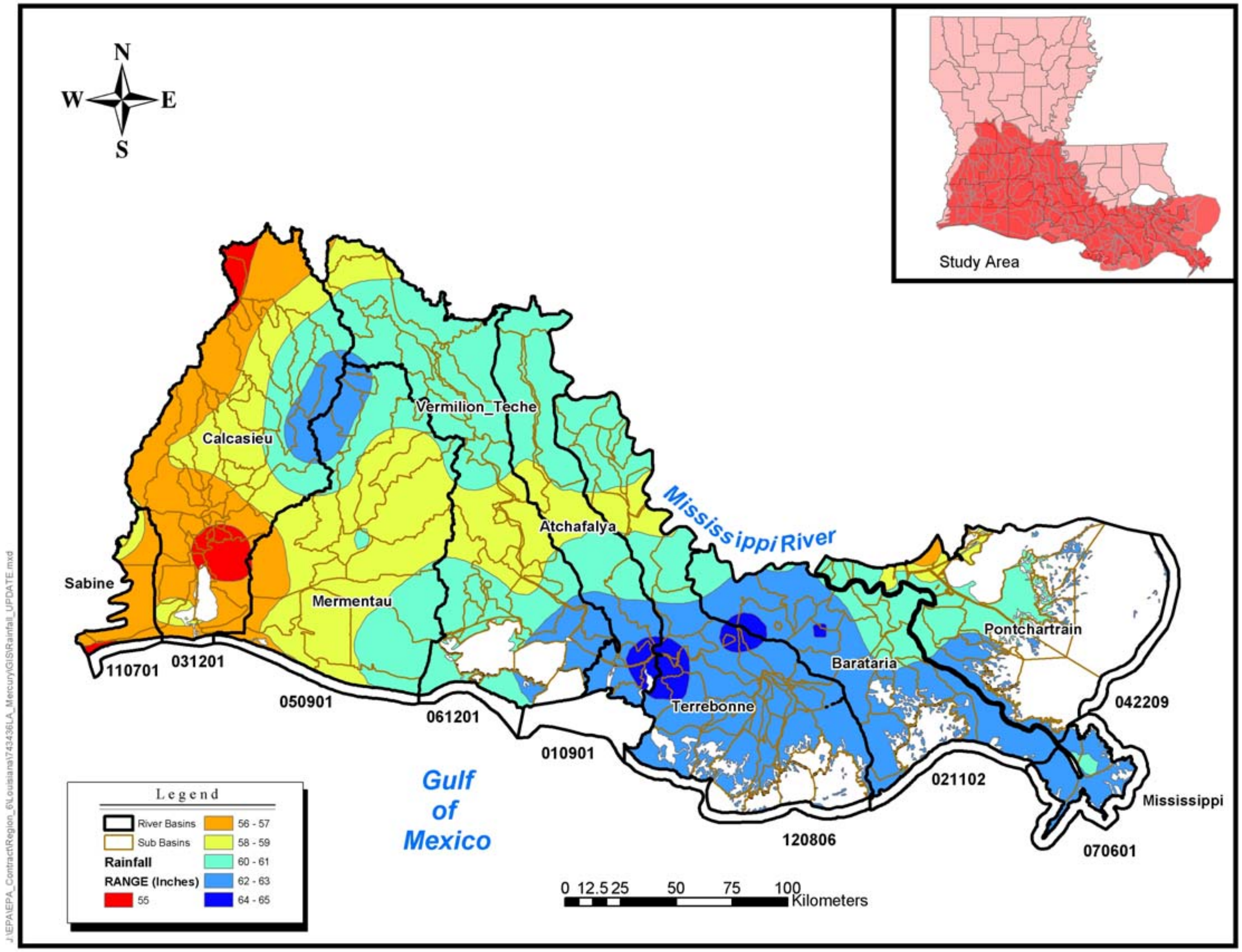


Figure 3.4 Soil Map

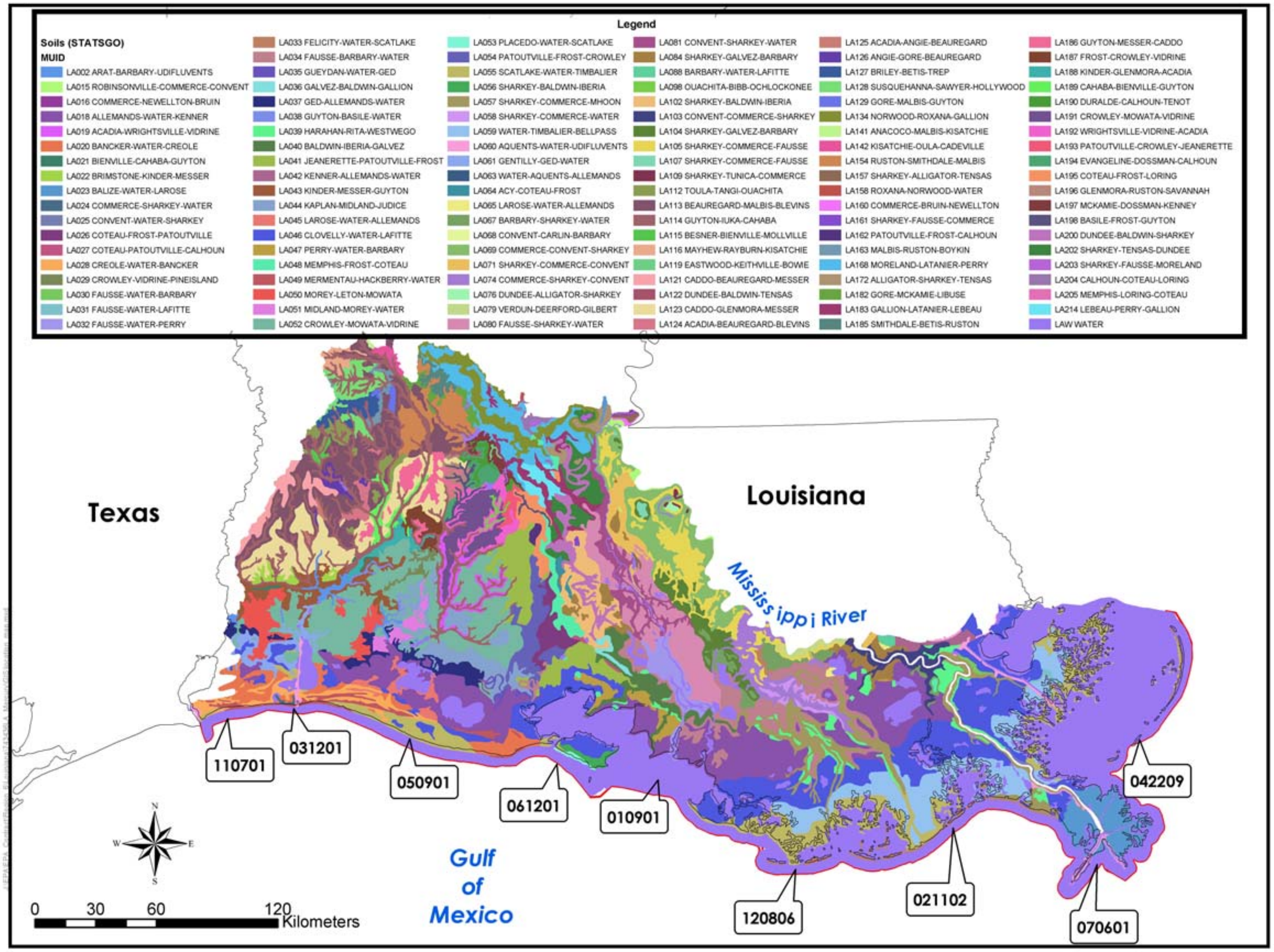


Figure 3.5 Land Use Map

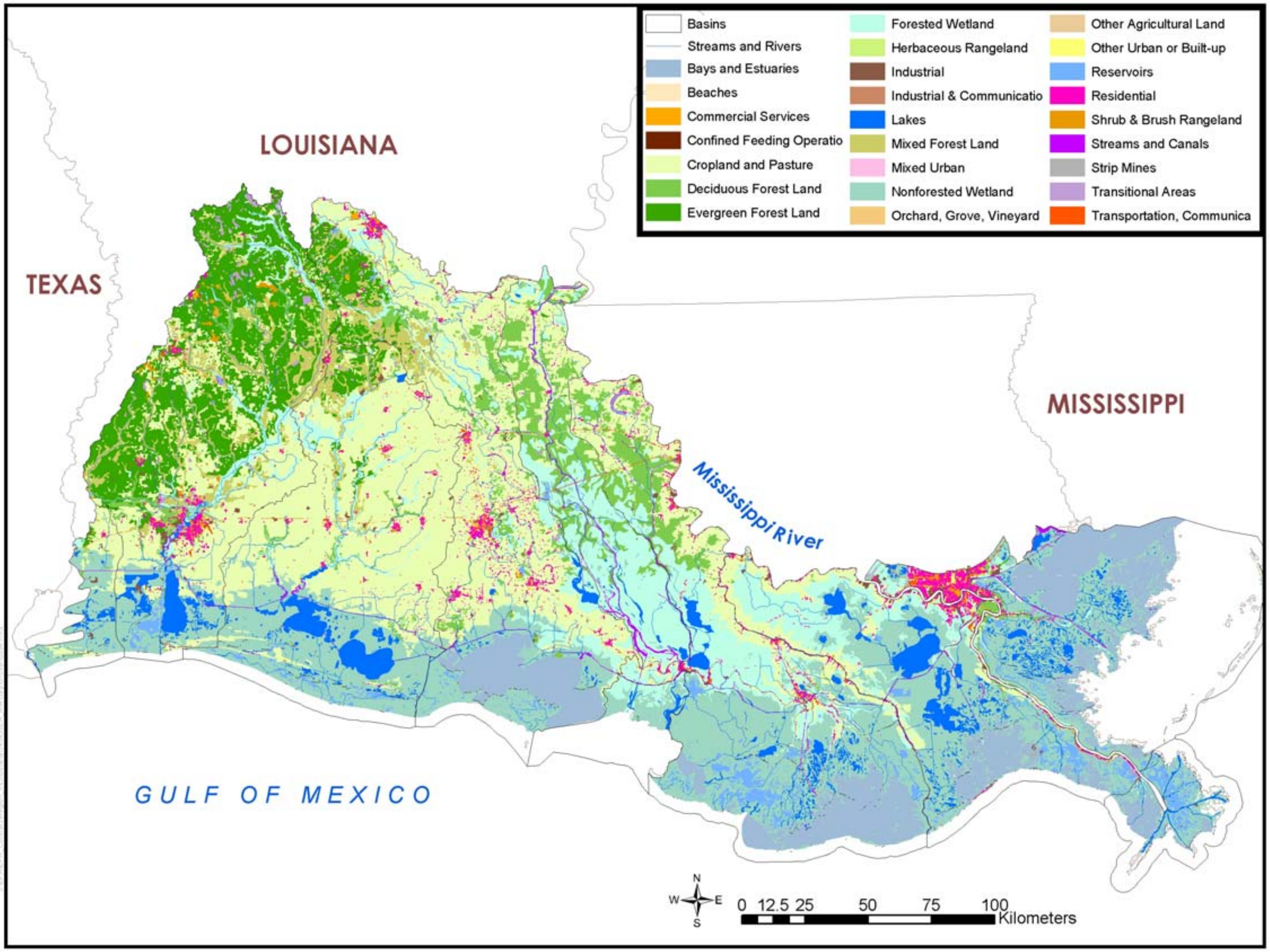


Table 3.3 Land Use Area

	Atchafalaya		Barataria		Calcasieu		Pontchartrain		Mermemtau	
	Basin 01		**Basin 02**		**Basin 03**		**Basin 04**		**Basin 05**	
Land Use	**% acres**	**acres**	**% acres**	**acres**	**% acres**	**acres**	**% acres**	**acres**	**% acres**	**acres**
Bays and Estuaries	7.6%	96,375	10.4%	162,640	0.0%	0	36.7%	431,089	0.0%	0
Beaches	0.0%	84	0.0%	0	0.0%	72	0.3%	3,904	0.0%	62
Commercial Services	0.0%	555	0.4%	6,996	0.4%	11,086	1.1%	13,484	0.2%	5,835
Confined Feeding Operations	0.0%	0	0.0%	0	0.0%	45	0.0%	0	0.0%	0
Cropland and Pasture	16.4%	207,197	11.7%	182,643	25.1%	643,922	0.6%	7,596	54.8%	1,291,771
Deciduous Forest Land	20.8%	263,394	0.8%	12,917	2.2%	56,689	1.3%	15,673	1.3%	30,799
Evergreen Forest Land	0.1%	1,161	0.0%	44	37.8%	968,577	0.1%	805	2.5%	59,577
Forested Wetland	41.0%	517,660	18.6%	289,691	5.1%	129,365	3.2%	38,011	4.6%	109,463
Herbaceous Rangeland	0.0%	0	0.0%	0	0.0%	1,091	0.0%	0	0.0%	0
Industrial	0.1%	1,207	0.7%	10,309	0.6%	15,148	0.7%	8,712	0.4%	9,196
Industrial and Commercial	0.0%	0	0.0%	0	0.0%	0	0.0%	228	0.0%	0
Lakes	1.1%	13,957	13.2%	205,456	4.4%	111,721	9.2%	108,507	7.0%	164,024
Mixed Forest Land	0.1%	1,158	0.0%	0	12.4%	316,899	0.0%	116	4.2%	99,377
Mixed Urban	0.0%	59	0.0%	532	0.1%	1,372	0.0%	154	0.1%	1,758
Nonforested Wetland	6.6%	83,908	39.2%	610,174	7.0%	179,060	38.8%	455,610	23.0%	542,024
Orchard, Grove, Vineyard	0.0%	29	0.1%	1,152	0.0%	478	0.0%	91	0.0%	252
Other Agricultural Land	0.0%	0	0.0%	10	0.0%	935	0.0%	0	0.0%	786
Other Urban or Built-up	0.2%	2,984	0.3%	4,786	0.1%	1,733	0.5%	5,533	0.0%	967
Reservoirs	0.6%	7,872	0.7%	10,381	0.1%	3,218	0.5%	5,636	0.1%	2,885
Residential	0.5%	6,735	2.4%	36,837	1.5%	39,449	4.2%	49,233	0.9%	21,973
Sandy Area (non-beach)	0.0%	0	0.0%	339	0.0%	0	0.0%	153	0.0%	0
Shrub & Brush Rangeland	0.0%	0	0.0%	0	0.8%	21,408	0.0%	0	0.0%	212
Streams and Canals	4.2%	53,236	0.7%	10,233	0.3%	7,901	1.2%	14,172	0.4%	10,535
Strip Mines	0.0%	0	0.1%	1,134	0.1%	2,357	0.0%	197	0.0%	78
Transitional Areas	0.3%	3,263	0.4%	5,587	1.7%	43,276	0.7%	7,873	0.2%	3,882
Transportation, Communication	0.2%	2,715	0.3%	4,987	0.2%	4,817	0.6%	7,502	0.2%	3,736
Total	**100.0%**	**1,263,553**	**100.0%**	**1,556,851**	**100.0%**	**2,560,618**	**100.0%**	**1,174,276**	**100.0%**	**2,359,192**

Table 3.3 Land Use Area (continued)

	Vermilion-Teche		Mississippi		Sabine		Terrebonne			
	Basin 06		**Basin 07**		**Basin 11**		**Basin 12**		**Total**	
Land Use	**% acres**	**acres**	**% acres**	**acres**	**% acres**	**acres**	**% acres**	**acres**	**% acres**	**acres**
Bays and Estuaries	11.3%	283,450	37.0%	96,420	0.0%	0	14.2%	331,248	9.8%	1,401,223
Beaches	0.0%	0	0.7%	1,749	0.1%	192	0.0%	129	0.0%	6,192
Commercial Services	0.7%	17,705	0.1%	261	0.1%	189	0.3%	7,187	0.4%	63,299
Confined Feeding Operations	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	45
Cropland and Pasture	46.0%	1,153,042	0.0%	0	24.4%	60,566	17.2%	400,514	27.7%	3,947,252
Deciduous Forest Land	6.5%	161,767	0.0%	0	1.7%	4,122	8.8%	205,122	5.3%	750,483
Evergreen Forest Land	5.3%	132,376	0.0%	0	1.7%	4,182	0.0%	0	8.2%	1,166,722
Forested Wetland	7.8%	194,645	0.8%	2,201	1.4%	3,382	15.4%	359,586	11.5%	1,644,003
Herbaceous Rangeland	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	1,091
Industrial	0.4%	9,140	0.4%	1,033	1.0%	2,539	0.4%	9,620	0.5%	66,904
Industrial and Commercial	0.0%	0	0.0%	0	0.0%	0	0.0%	0	0.0%	228
Lakes	1.4%	34,205	16.9%	43,993	6.1%	15,238	7.4%	171,651	6.1%	868,754
Mixed Forest Land	4.7%	118,077	0.0%	0	0.8%	2,030	0.0%	0	3.8%	537,657
Mixed Urban	0.1%	1,643	0.0%	0	0.0%	0	0.1%	1,466	0.0%	6,985
Nonforested Wetland	11.2%	281,845	37.0%	96,244	60.5%	150,519	32.8%	764,619	22.2%	3,164,005
Orchard, Grove, Vineyard	0.0%	600	0.0%	2	0.0%	94	0.0%	235	0.0%	2,933
Other Agricultural Land	0.0%	978	0.0%	0	0.0%	0	0.0%	27	0.0%	2,736
Other Urban or Built-up	0.2%	4,084	0.0%	0	0.0%	0	0.1%	2,505	0.2%	22,592
Reservoirs	0.3%	7,599	0.1%	291	0.1%	145	0.4%	9,768	0.3%	47,795
Residential	3.2%	80,471	0.1%	220	0.4%	977	1.8%	41,909	1.9%	277,804
Sandy Area (non-beach)	0.0%	0	0.1%	343	0.4%	1,114	0.0%	0	0.0%	1,948
Shrub & Brush Rangeland	0.0%	106	0.0%	0	0.1%	341	0.0%	0	0.2%	22,066
Streams and Canals	0.3%	7,134	6.6%	17,240	0.7%	1,862	0.8%	19,480	1.0%	141,794
Strip Mines	0.1%	2,510	0.0%	0	0.0%	0	0.0%	33	0.0%	6,309
Transitional Areas	0.4%	8,867	0.0%	125	0.3%	681	0.1%	2,285	0.5%	75,838
Transportation, Communication	0.3%	7,284	0.1%	287	0.2%	431	0.3%	6,872	0.3%	38,632
Total	**100.0%**	**2,507,529**	**100.0%**	**260,410**	**100.0%**	**248,603**	**100.0%**	**2,334,257**	**100.0%**	**14,265,289**

SECTION 4
PROBLEM DEFINITION AND ENDPOINT IDENTIFICATION

4.1 PROBLEM DEFINITION

This TMDL report meets the provisions of the federal CWA Section 303(d), which requires the LDEQ or the USEPA to develop a pollutant load allocation for each waterbody/pollutant combination identified on the list established as part of the 2002 Consent Decree (United States 2002). The list established in the Consent Decree and later modified by LDEQ included Hg in king mackerel fish tissue as a pollutant of concern in subsegments 010901, 021102, 031201, 042209, 050901, 061201, 070601, 110701, and 120806. USEPA has established mercury TMDLS for subsegments 031201, 050901 and 061201. This report addresses the six remaining subsegments. Mercury is common in edible tissues of estuarine/marine fish such as king mackerel harvested from the Gulf of Mexico (Ache *et al*. 2000). The fish consumption advisory for all Coastal Bays and Gulf Waters of Louisiana was jointly issued by the LDHH, the LDEQ, and the LDWF in September 1997. The fish consumption advisory is provided in Appendix A.

The LDEQ and LDHH coordinate the assessment of health risks for consumption of fish, and jointly issue advisories if warranted. The LDWF and the Louisiana Department of Agriculture and Forestry can also participate in the health risk assessment. When the average Hg concentration exceeds 0.5 parts per million (mg/kg) in fish or shellfish, a fish consumption advisory may be issued. The concentration of Hg in king mackerel exceeds 1.0 mg/kg in numerous locations in Gulf Waters along the Louisiana coast; therefore, a precautionary fish consumption advisory for the area was issued by the LDEQ, LDHH, and LDWF. Based on this fish tissue data, the Coastal Bays and Gulf Waters exceed LDEQ's narrative water quality criterion for toxic pollutants. This TMDL report was developed to address the elevated levels of Hg in fish tissue for the LDEQ subsegments identified in the consumption advisory area and not previously addressed.

4.2 LDEQ SURFACE WATER QUALITY STANDARDS

Water quality standards for the State of Louisiana were promulgated in the Louisiana Administrative Code (LAC), Title 33, Part IX Subpart 1 Chapter 11 (LDEQ 2004b). The designated uses for all nine subsegments are primary contact recreation, secondary contact recreation, propagation of fish and wildlife, and oyster propagation.

The applicable marine water acute and chronic aquatic life criteria for dissolved Hg are 2.0 micrograms per liter (µg/L) and 0.025 µg/L, respectively. Furthermore, if the 4-day average concentration for dissolved Hg exceeds the marine chronic aquatic life criteria of 0.025 µg/L more than once in a 3-year period, the edible portion of aquatic species of concern must be analyzed to determine whether the concentration of Hg exceeds the Food and Drug Administration (FDA) action level of 1.0 milligrams per kilogram (mg/kg). LDEQ must notify USEPA if the action level is exceeded and take appropriate action such as issuance of a fish consumption advisory. While there are no known violations of the numeric ambient water quality criterion for Hg, the Coastal Bays and Gulf Waters of Louisiana do not meet the narrative WQS for toxic substances because of the fish consumption advisory.

The LDEQ narrative water quality standard for toxic substances states:

> *No substance shall be present in the waters of the state or the sediments underlying said waters in quantities that alone or in combination will be toxic to human, plant, or animal life or significantly increase health risks due to exposure to the substances or consumption of contaminated fish or other aquatic life.*

For waterbodies in the fish consumption advisory areas to meet the designated use designed to protect human health, the narrative criteria for toxic substances must be met.

4.3 ENDPOINT IDENTIFICATION

40 CFR §130.7(c)(1) states that "TMDLs shall be established at levels necessary to attain and maintain the applicable narrative and numerical water quality standard." In certain circumstances, such as with fish consumption advisories, it is possible for numeric water quality criteria to be met, but the designated use still not be met. Since the primary objective of a TMDL is to restore and maintain the designated uses of impaired waterbodies, an endpoint or target must be established to determine if this goal has been attained. In the case of these TMDLs for mercury, restoring and maintaining the "fishable" use and protection of human health represent the water quality goals to be achieved by implementing the pollutant load allocations defined in this report.

An endpoint for Hg can be established as a water numeric criterion, a sediment concentration, or a fish tissue value. There are no documented exceedances of the dissolved Hg water quality criteria in the fish consumption advisory area, yet fish tissue concentrations are elevated. This phenomenon is described in more detail in Section 6. Thus, a dissolved mercury numeric water quality criterion would not provide an adequate endpoint for these TMDLs. In addition, there are no sediment concentration data in the fish consumption advisory area which preclude developing correlations with fish tissue concentrations. Thus, sediment concentration is not a good endpoint for these TMDLs.

When the edible fish tissue Hg concentration exceeds 1.0 mg/kg, LDEQ and LDHH will recommend a limited consumption advisory for certain fish species and/or no consumption advisory for other fish species for children under the age of 7 years and pregnant or breast feeding women, and limited consumption for the general population. In addition, the LDEQ and LDHH will consider issuing a limited consumption advisory for children under the age of 7 years and pregnant or breast feeding women when the edible fish tissue Hg concentration exceeds 0.5 mg/kg (LDEQ 2000).

Since the LDEQ WQSs do not include a numeric water quality criterion for mercury explicitly calculated to protect human health, it is necessary to use the narrative criterion for toxic substances as described above in Subsection 4.2 as the basis for setting the water quality target for these TMDLs. The most reasonable endpoint for establishing a TMDL is the fish tissue concentration of mercury of 0.5 mg/kg, which is the basis of the fish consumption advisory issued by LDHH and LDEQ to protect the most sensitive population including children under the age of 7 years and pregnant or breast feeding women. The benefits of using this fish tissue criterion are:

1. It accounts for spatial and temporal complexities that occur in aquatic systems;
2. It accounts for bioaccumulation and biomagnification in the aquatic food chain; and
3. It is more directly tied to the goal of protecting public health from consumption of edible fish.

In addition, an endpoint of 0.5 mg/kg in fish tissue was used in previous mercury TMDLs in Louisiana (USEPA 2003). As a numeric translator for this narrative standard, an endpoint of 0.5 mg/kg methylmercury in fish tissue has been selected as the target for these TMDLs. Methylmercury is mercury converted by bacteria or other processes into an organic (containing carbon) compound such as CH_3HgCl or CH_3HgOH. Methylmercury is the dominant form of mercury that exists in the environment and is readily bioaccumulated by fish, humans, and other organisms; therefore, essentially all Hg found in fish is methylmercury (Wiener, *et al.* 2003). Similar to the assumption made in *A Survey of the Occurrence of Mercury in the Fishery Resources of the Gulf of Mexico* (Ache, *et al.* 2000), total mercury and methylmercury measurements are deemed equivalent measures in tissue samples for purposes of this assessment report. Figure 4.1 on the following page indicates that the concentration of Hg in king mackerel tissue exceeds the endpoint of 0.5 mg/kg in most instances.

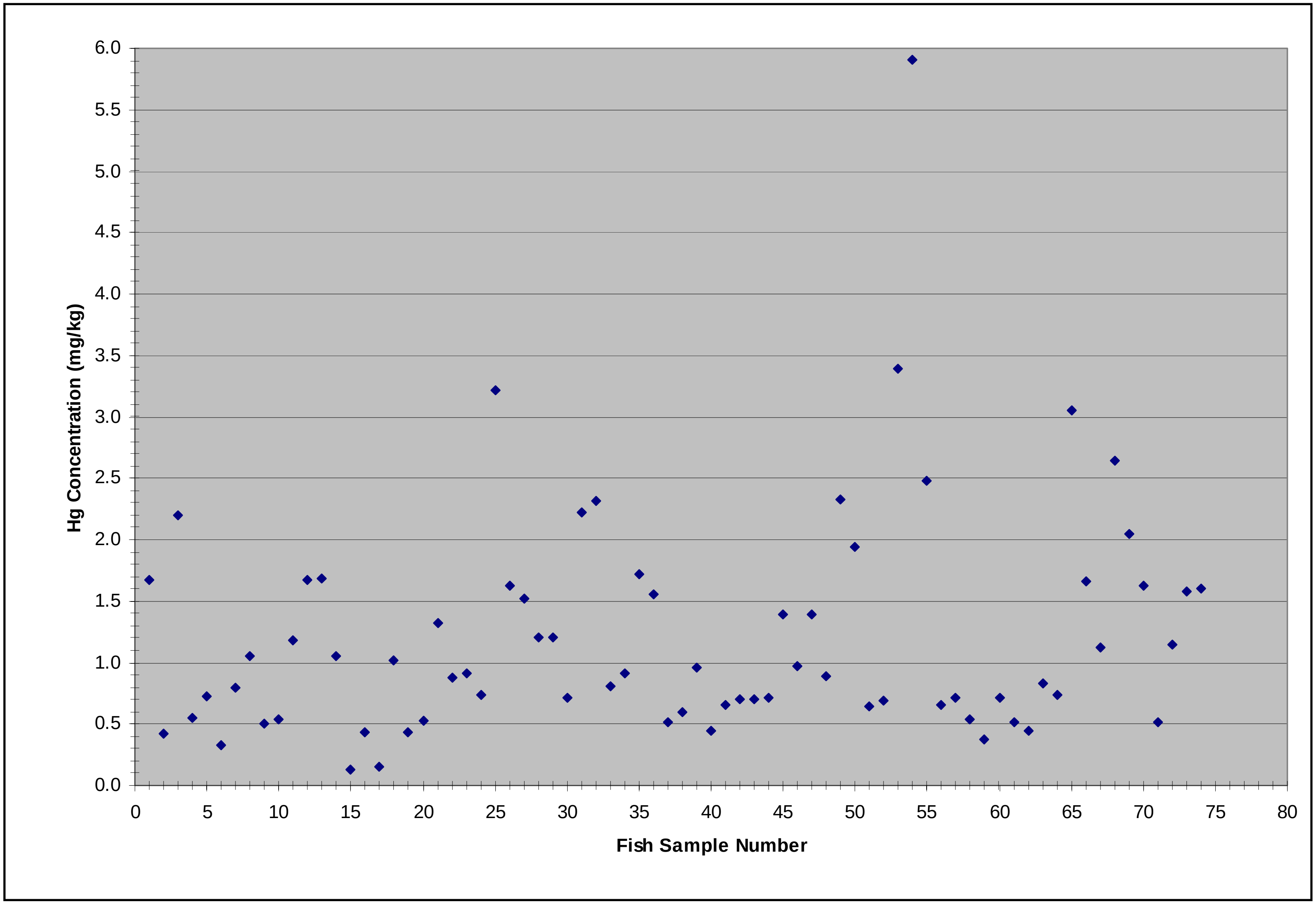
4.4 RELATIONSHIP BETWEEN TMDL TARGET AND POLLUTANT LOAD REDUCTION ESTIMATE

A connection must be made between the mercury concentration in fish tissue and the point source and nonpoint source loads of mercury to the environment. This is necessary to establish pollutant load reductions that will lead to a decrease in the mercury concentration in fish tissues so the fish consumption advisory can be lifted and the "fishable" use restored.

As part of on-going studies of the Florida Everglades, an aquatic model, the Everglades Mercury Cycle Model (E-MCM), was used to understand mercury cycling in the Everglades through the food chain to top-level predator fish. The E-MCM model predicts a linear relationship between atmospheric deposition and fish tissue concentration based on extensive field data used to calibrate the model (USEPA 2003a). This means for a given percent reduction in Hg load, a corresponding percent reduction in fish tissue concentration can be expected.

Since hydrodynamic modeling was not done for these TMDLs because of time constraints and a lack of data to calibrate a model, USEPA assumed a linear relationship between atmospheric deposition and fish tissue concentrations for these TMDLs. Guided by this assumption, these TMDLs use the observed average king mackerel tissue concentration (see Subsection 7.2) to calculate the percent decrease in fish tissue concentration needed to achieve the target level of 0.5 mg/kg fish tissue methylmercury concentration. It is assumed that if the total mercury body burden of king mackerel were reduced to less than 0.5 mg/kg, each subsegment would achieve its "fishable" use. This premise is adopted in the calculation of TMDLs for the Coastal Bays and Gulf Waters of Louisiana.

Figure 4.1 Mercury Concentration in King Mackerel Tissue



SECTION 5 DATA ASSESSMENT

The LDEQ mercury monitoring program was started in 1994, and during the past 10 years water, sediment, and fish tissue have been sampled at 498 sites in 300 waterbodies to determine the extent of contamination and to establish health advisories when necessary (LDEQ 2004a). The LDWF has primary responsibility for collecting samples in the Gulf of Mexico, but results are maintained in the LDEQ database. This section summarizes available data for mercury concentrations in ambient water, fish tissue, sediment, and from atmospheric deposition.

5.1 AMBIENT WATER DATA

The LDEQ has sampled mercury in ambient water using clean techniques since 2001. Table 5.1 shows the dissolved Hg concentrations from various LDEQ water quality monitoring stations, provided for this report by the LDEQ Water Quality Assessment Division, for six of the nine Coastal Bays and Gulf Waters of Louisiana collected between 2001 and 2004. Clean sampling data for mercury are not currently available from subsegments 042209 and 120806. These data show there have been no exceedances of the ambient water quality chronic criterion of 0.025 µg/L along the Louisiana coast. The data also show there are no specific geographic locations within the Coastal Bays and Gulf Waters of Louisiana that indicate a specific concern for high levels of mercury in the water column. The location of the various LDEQ water quality monitoring stations from where the mercury data in Table 5.1 were collected are shown in Figure 5.1.

5.2 FISH TISSUE DATA

LDEQ, in conjunction with LDWF, has sampled mercury in fish tissue since 1996. Table 5.2 shows the Hg concentration for each fish species sampled from the Gulf of Mexico. Fish tissue data for subsegment 110701 is not available. These data show that the average fish tissue concentrations of Hg exceed the endpoint of 0.5 mg/kg in at least one species in seven of the eight subsegments along the Louisiana coast, with no data available for subsegment 110701. King mackerel were collected throughout the Gulf of Mexico, and in each sampling location that King mackerel were sampled, the average mercury concentration exceeded the endpoint of 0.5 mg/kg. Appendix B includes a complete listing of the available fish tissue concentration data, provided for this report by the LDEQ Water Quality Assessment Division, for all fish species summarized in Table 5.2. Data included in *A Survey of the Occurrence of Mercury in the Fishery Resources of the Gulf of Mexico* (Ache, *et al.* 2000) are consistent with the LDWF/LDEQ fish tissue monitoring results. Fish tissue data show that under ambient conditions king mackerel, demonstrate elevated concentrations of mercury independent of the sampling location in the Gulf of Mexico (Ache, *et al.* 2000). Locations of the various sites in the Gulf of Mexico where king mackerel were collected for analysis are also shown in Figure 5.1.

Table 5.1 LDEQ Dissolved Mercury Data in Coastal Bays and Gulf Waters

Subsegment	Site No.	Description	Date	Result (µg/L)
010901	1204	Atchafalaya Bay south of Burns, Louisiana	01/08/02	0.00207
			04/02/02	0.00024
			04/02/02	0.00147
			04/02/02	0.00149
			07/09/02	0.00041
			07/09/02	0.00057
			07/09/02	0.00055
			10/19/02	0.00065
			10/19/02	0.00065
021102	0924	Unnamed canal between Pass Fourchon and Bay Champagne, Louisiana	03/08/04	0.00047
			06/01/04	0.00015
			06/01/04	0.00015
			06/01/04	0.00056
	0927	Gulf of Mexico south of Belle Pass, Louisiana	06/15/04	0.00016
			06/15/04	0.00025
			06/15/04	0.00026
031201	0852	Calcasieu River Coastal Waters Southeast of Cameron Jetties, Louisiana	06/07/04	0.00024
			06/07/04	0.00022
			06/07/04	0.00708
			06/07/04	0.00744
			06/07/04	0.00021
050901	2114	Gulf of Mexico southwest of Grand Chenier, Louisiana	01/06/03	0.00218
			04/21/03	0.00042
			07/07/03	0.00029
			12/16/03	0.00075
070601	1092	East Bay near Joseph Bayou	06/20/01	0.00060
			09/12/01	0.00040
			12/04/01	0.00047
110701	1170	Gulf of Mexico south of Louisiana Point, Louisiana	01/07/02	0.00017
			01/07/02	0.00255
			07/08/02	0.00015
			07/08/02	0.00029
			10/08/02	0.00548
			10/08/02	0.00

Figure 5.1 LDEQ Water Quality Monitoring and Gulf of Mexico Sampling Stations

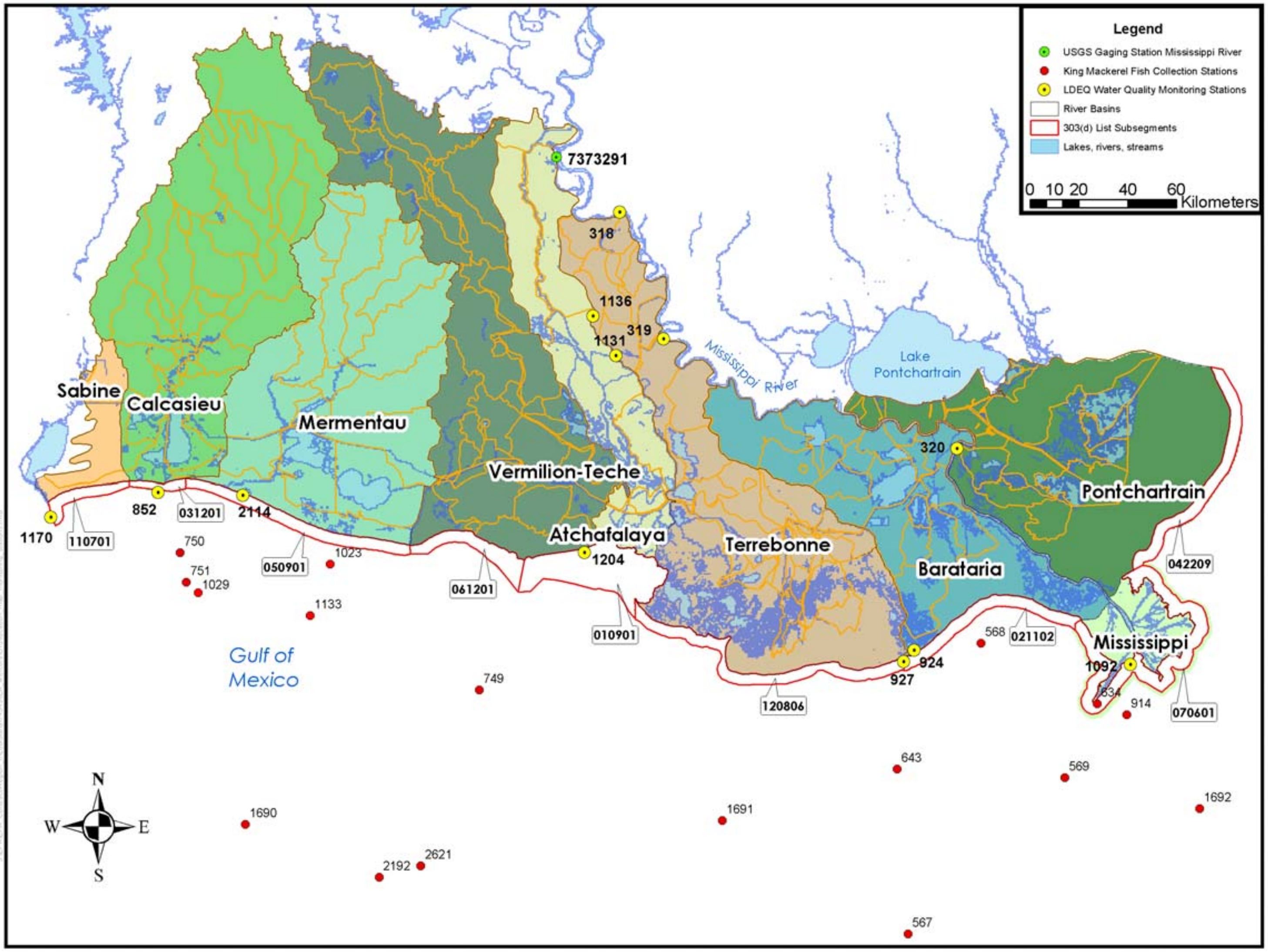


Table 5.2 Mercury in Fish Tissue (mg/kg wet weight)

Subsegment	Species	Min Hg Conc	Avg Hg Conc	Max Hg Conc	No. Fish
010910	Greater Amberjack	0.4728	0.4728	0.4728	1
021102	**King Mackerel**	**0.3300**	**0.9837**	**2.2020**	**6**
	Spanish Mackerel	0.2140	0.2140	0.2140	1
	Red Snapper	0.0200	0.0488	0.0776	2
	Lane Snapper	0.0486	0.0486	0.0486	1
	Cobia	0.0130	0.1263	0.1850	3
	Jack Crevalle	0.2000	0.2000	0.2000	1
	Red Drum	0.0452	0.1424	0.3053	3
	Spotted Seatrout	0.0985	0.1783	0.2885	3
031201	**King Mackerel**	**0.1334**	**1.1098**	**1.6850**	**11**
	Spanish Mackerel	0.1833	0.3005	0.4656	6
	Red Snapper	0.1118	0.1309	0.1483	3
	Cobia	0.2723	0.2723	0.2723	1
	Red Drum	0.0677	0.4390	0.8103	2
	Spotted Seatrout	0.0784	0.1080	0.1401	5
	Triple Tail	0.0409	0.0523	0.0697	3
	Florida Pompano	0.1509	0.1509	0.1509	1
42209	Cobia	0.7760	0.7760	0.7760	1
050901	**King Mackerel**	**0.4383**	**1.3071**	**2.3190**	**19**
	Red Snapper	0.1118	0.3423	0.9320	7
	Cobia	0.0828	0.9821	2.1670	7
	Dolphin Fish	0.0559	0.1587	0.3145	8
	Greater Amberjack	0.4264	0.6764	1.0780	8
	Warsaw Grouper	0.4028	0.4493	0.4958	2
	Scamp Grouper	0.4519	0.5388	0.6573	4
	Yellowedge Grouper	0.4742	0.4742	0.4742	1
	Blackfin Tuna	0.2436	0.8521	1.6700	5
	Yellowfin Tuna	0.1150	0.1177	0.1203	2
	Wahoo	0.4655	0.4655	0.4655	1
061201	**King Mackerel**	**0.4421**	**0.6513**	**0.9533**	**7**
	Spotted Seatrout	0.0558	0.1423	0.4557	10
	Croaker	0.0673	0.0673	0.0673	1
070601	**King Mackerel**	**0.3795**	**1.5133**	**5.9040**	**17**
	Red Snapper	0.0560	0.2063	0.8464	9
	Cobia	0.1546	0.4017	0.6451	7
	Dolphin Fish	0.0568	0.1460	0.4136	8
	Greater Amberjack	0.2116	0.5007	0.9254	8
	Warsaw Grouper	0.2899	0.4419	0.5939	2
	Scamp Grouper	0.1174	0.1174	0.1174	1
	Gag Grouper	0.0829	0.1460	0.2211	3
	Blackfin Tuna	0.3281	0.9004	1.4270	8
	Yellowfin Tuna	0.2567	0.2630	0.2692	2
120806	**King Mackerel**	**0.4390**	**1.3942**	**3.0540**	**14**
	Red Snapper	0.0536	0.4956	1.1790	11
	Cobia	0.5504	1.5921	3.0280	11
	Dolphin Fish	0.0167	0.0946	0.3555	8
	Greater Amberjack	0.1928	0.5224	0.9447	11
	Warsaw Grouper	0.2036	0.3698	0.4775	4
	Scamp Grouper	0.3785	0.3785	0.3785	1

Subsegment	Species	Min Hg Conc	Avg Hg Conc	Max Hg Conc	No. Fish
	Gag Grouper	0.1798	0.4059	0.1793	5
	Yellowedge Grouper	0.1310	0.1310	0.1310	1
	Blackfin Tuna	0.0992	0.6835	1.1770	8
	Yellowfin Tuna	0.0781	0.0781	0.0781	1

Table 5.3 is a summary of the fish tissue Hg concentrations by species for all the sample sites in the Gulf of Mexico off the Coast of Louisiana.

Table 5.3 Mercury in Fish Tissue by Species (mg/kg wet weight)

Species	Min Hg Conc	Avg Hg Conc	Max Hg Conc	No. Fish
King Mackerel	0.1334	1.2129	5.9040	74
Blackfin tuna	0.0992	0.8120	1.6700	21
Cobia	0.0130	0.6918	3.0280	30
Greater Amberjack	0.1928	0.5665	1.0780	27
Wahoo	0.4655	0.4655	0.4655	1
Warsaw Grouper	0.2036	0.4203	0.5939	8
Scamp Grouper	0.1174	0.3449	0.6573	6
Yellowedge Grouper	0.1310	0.3026	0.4742	2
Red Drum	0.0452	0.2907	0.8103	5
Gag Grouper	0.0829	0.2760	0.7913	8
Spanish Mackerel	0.1833	0.2573	0.4656	7
Red Snapper	0.0200	0.2448	1.1790	32
Yellowfin Tuna	0.0781	0.1529	0.2692	5
Florida Pompano	0.1509	0.1509	0.1509	1
Spotted Seatrout	0.0558	0.1429	0.4557	18
Dolphin Fish	0.0167	0.1331	0.4136	24
Croaker	0.0673	0.0673	0.0673	1
Triple Tail	0.0409	0.0523	0.0697	3
Lane Snapper	0.0486	0.0486	0.0486	1
Jack Crevalle	0.0200	0.0200	0.0200	1

5.3 SEDIMENT DATA

No mercury sediment data are available from the 303(d)-listed subsegments that comprise the Coastal Bays and Gulf Waters of Louisiana. However, mercury in sediment data collected from 2001 through 2003 are summarized in Table 5.4 for all the adjacent and contributing watersheds averaged by river basin. The complete mercury in sediment dataset used to derive Table 5.4, provided for this report by the LDEQ Environmental Planning Division, is located in Appendix F. The locations of the various LDEQ water quality monitoring stations where sediment data were collected are also shown in Figure 5.1.

Table 5.4 Mercury and Methyl-Mercury in Sediments

Basin No.	Basin Name	Hg (mg/kg)	Methyl-Hg (mg/kg)
01	Atchafalaya	0.1067	0.00110
02	Barataria	0.0949	0.00139
03	Calcasieu	0.1200	0.00095
04	Lake Pontchartrain	0.1202	0.00078
05	Mermentau	0.0804	0.00072
06	Vermilion-Teche	0.1225	0.00103
07	Mississippi	0.0445	ND
11	Sabine	0.0931	0.00109
12	Terrebone	0.1146	0.00210

ND = No Data

5.4 ATMOSPHERIC DEPOSITION DATA

There are four ambient air monitoring stations in Louisiana that are part of the National Atmospheric Deposition Program Mercury Deposition Network (NADP MDN 2004) as depicted in Figure 5.2.

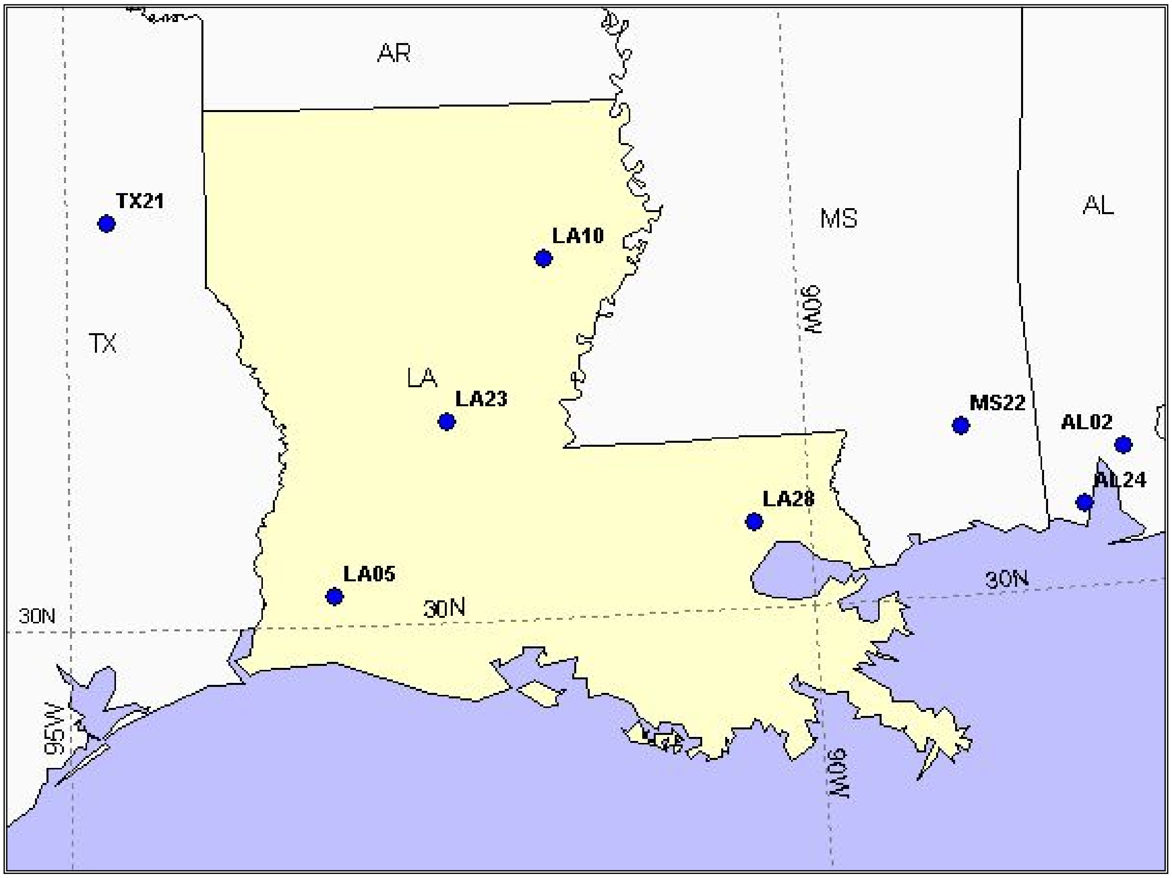
Weekly results of both Hg concentrations in precipitation and Hg wet deposition are available online for each station at http://nadpdata/sws.uiuc.edu. Table 5.5 is a summary of the average annual Hg concentrations in precipitation and average annual Hg wet deposition data for each station.

Table 5.5 Average Annual Mercury MDN Data

	NADP MDN Monitoring Station							
	LA05		LA10		LA23		LA28	
	Avg Hg Conc	Avg Hg Dep	Avg Hg Conc	Avg Hg Dep	Avg Hg Conc	Avg Hg Dep	Avg Hg Conc	Avg Hg Dep
Year	ng/L	ng/m^2-wk	ng/L	ng/m^2-wk	ng/L	ng/m^2-wk	ng/L	ng/m^2-wk
1998	10.1	122	8.5	232	ND	ND	10.5	100
1999	16.9	264	15.6	260	ND	ND	18.1	249
2000	19.5	219	15.9	248	ND	ND	15.9	218
2001	14.0	345	26.0	357	12.9	324	13.7	278
2002	10.5	228	12.5	268	14.0	250	16.9	259
2003	20.1	247	12.2	284	15.4	251	13.7	315
Average	16.1	253	15.8	282	14.1	175	15.4	256

ND - No Data

Figure 5.2 MDN Monitoring Station Locations



Source: NADP MDN http://nadp.sws.uiuc.edu/sites/sitemap.asp?net=MDN&state=la

Releases of toxic substances, including mercury and mercury compounds, must be reported annually to the USEPA as part of the Toxic Release Inventory (TRI) program required by Title III of the Emergency Planning and Community Right to Know Act (EPCRA). Facilities must annually report any releases to the air, water, and land. Releases of air toxins, including Hg, must be reported annually to LDEQ as part of the Toxics Emission Data Inventory (TEDI) as required by LDEQ regulations. There are differences in the emissions reported under TRI and TEDI since the reporting thresholds are not the same. Table 5.6 includes mercury air emissions data by Standard Industrial Classification (SIC) code for Louisiana. Statewide 2002 TRI and 2002 TEDI data show air emissions of 4,015 pounds per year (lbs/yr) and 1,519 lbs/yr, respectively. Table 5.6 is provided for information purposes only.

Table 5.6 Louisiana Mercury Air Emission Data

SIC	Industry Type	2002 TRI (lbs/yr)*	2002 TEDI (lbs/yr)**
24	Lumber/Wood	0	3
26	Paper	163	217
28	Chemicals	2,241	1,262
29	Petroleum Refining	138	36
32	Stone/Clay/Glass/Concrete	6	0
33	Primary Metals	2	0
49	Electric Utilities	1,262	1
20-39	Multiple Codes	203	0
Total		4,015	1,519

* Mercury + Mercury Compounds
** Mercury

SECTION 6
IDENTIFICATION OF POLLUTANT SOURCES

6.1 MERCURY CYCLE

Mercury is readily cycled in the earth's surface with the atmosphere playing an important role in its transport (Fitzgerald and Mason 1996; Lamborg *et al.* 2002). Mercury sources to the atmosphere include both naturally occurring and anthropogenic sources. Mercury deposited into streams and lakes emanates from local, regional, and global scale sources, making it nearly impossible to pinpoint the exact source of contamination. Although there are many potential sources, the greatest anthropogenic source of mercury in Louisiana appears to be air emissions from global sources and local sources (USEPA 2004). Mercury is also released into water and air by medical waste and other incinerators, coal-fired electric power plants, chlor-alkali facilities, and improper disposal of mercury-containing products (LDEQ 2003).

Figure 6.1 illustrates the transformation and movement of mercury in atmospheric, soil, and aqueous systems. Mercury exists in the environment in different forms: Hg^0 (elemental), Hg(II) (inorganic), and methylmercury (organic). In the atmosphere, mercury exists almost entirely in the relatively insoluble gaseous elemental state Hg^0 which can be transported over long distances from the source (Fitzgerald and Mason 1996). Elemental Hg^0 can be converted in the atmosphere to the more soluble inorganic forms referred to as reactive gaseous mercury (RGM) that can be readily deposited to land and water (Lindberg and Stratton 1998). Wet and dry deposition is the mechanism by which mercury emitted into the atmosphere is transported to land and surface water. Methylation of mercury occurs primarily in surficial sediments by sulfate-reducing bacteria whose oxygen concentration requirements are low and other environmental conditions are favorable to sulfate-reducing bacteria (Gilmour *et al.* 1998, Ullrich *et al.* 2001). Methylmercury is the principal form of mercury that can be readily bioaccumulated by fish, humans, and other organisms; therefore, essentially all mercury found in fish is methylmercury (Wiener *et al.* 2003).

This mobilization of mercury through aquatic systems is shown in Figure 6.2. For humans and wildlife, the mercury exposure pathway of particular concern is consumption of fish tissue with elevated levels of methylmercury. Once methylmercury enters the food chain, it binds with protein in muscle tissue of fish and other living organisms (USEPA 1997; 1998). Methylmercury is lost very slowly from fish tissue, on the order of years (Trudel and Rasmussen 1997). Mercury levels tend to increase at higher trophic levels through biomagnification. Because methylmercury is almost completely absorbed in the digestion process, the level of methylmercury becomes magnified as progressively larger predators ingest organisms contaminated by mercury (LDEQ 2000, Weiner *et al.* 2003).

Figure 6.1 Mercury Cycle

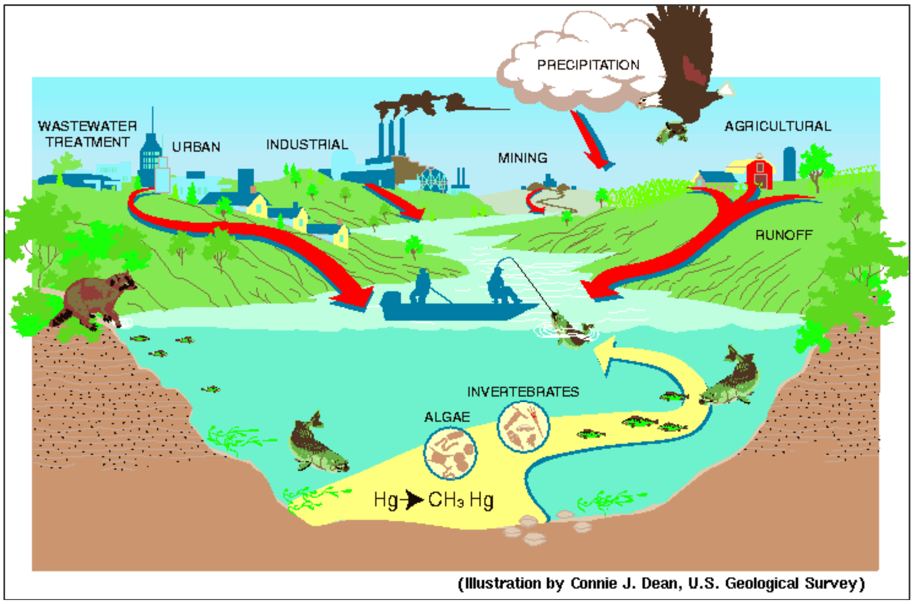
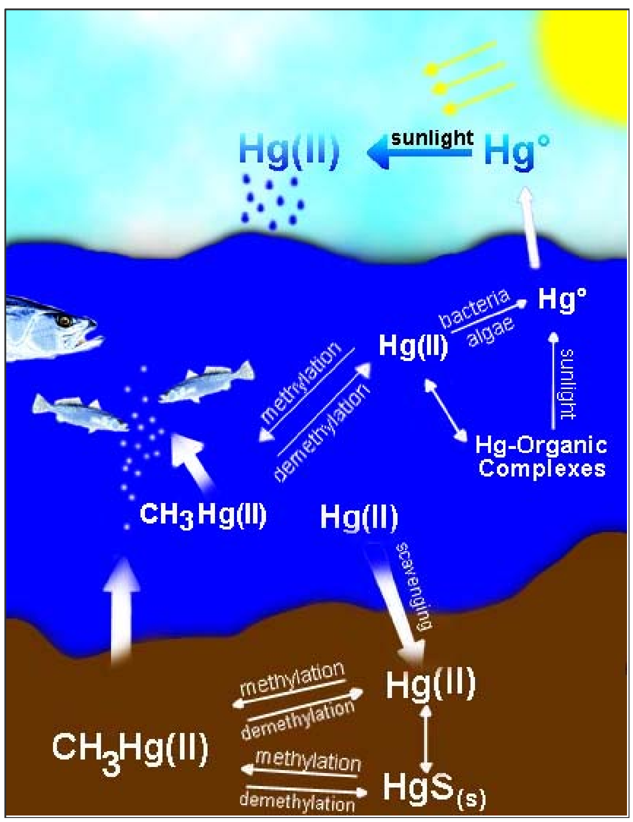


Figure 6.2 Aquatic Ecosystem Mercury Pathways



(http://loer.tamug.tamu.edu/Research/Mercury/mercury.htm)

6.2 METHYLMERCURY FORMATION AND DESTRUCTION

The concentration of methylmercury in aquatic ecosystems is the net result of two competing processes, mercury methylation and demethylation. Production of methylmercury in aquatic systems is controlled by several physical, chemical, and biological factors (Ullrich *et al.,* 2001; Benoit *et al.* 2003). As mercury is methylated principally by sulfate-reducing bacteria, factors which stimulate these microorganisms favor the formation of methylmercury. Important environmental parameters influencing the methylation of mercury include reduction-oxidation conditions, sulfide, sulfate, and dissolved organic carbon (DOC) levels, pH, and temperature. Mercury demethylation occurs both biotically and abiotically in both aerobic and anaerobic environments by enzymatic and non-enzymatic pathways (Marvin-DiPasquale, *et al*. 2000).

Studies show that local geochemical differences in waterbodies, especially high DOC content, can affect methylation rates and ultimately mercury bioaccumulation in fish. In 1991, the Wisconsin Department of Natural Resources began the Wisconsin Background Trace Metals Study. Results of the study show that partitioning and speciation of mercury in Wisconsin rivers was strongly influenced by land use and land cover characteristics of the watershed. Highest total mercury and methylmercury yields were observed from sites that passed through wetlands (USEPA 1995). It is believed that mercury is complexed and transported in the dissolved phase with DOC. High levels of DOC in both surface waters and pore waters are a characteristic of wetlands. With wetlands comprising 34 percent of land use in the adjacent coastal and contributing watersheds of the study area, methylation of mercury is likely occurring.

6.3 SOURCES OF MERCURY CONTAMINATION

Mercury is a naturally occurring element, half of which moves through the environment from natural activities and processes, and the other half emanates from anthropogenic sources (Nriagu 1989; Fitzgerald and Mason 1996; Lamborg *et al*. 2002)). There are numerous potential sources of mercury to Louisiana waters, including air emissions, natural geologic deposits, industrial/municipal discharges, disposal of drilling muds from off shore oil production, previously contaminated sediment, and fugitive sources such as discarded batteries or containers of elemental mercury (Krabbenhoft and Rickert 1995; Gordon Undated). This report does not attempt to estimate mercury loading resulting from dredging activity throughout the Louisiana coastal region since dredging activities do not add mercury to coastal waters, but simply redistribute existing mercury. Inputs of mercury to coastal areas include rivers, atmospheric deposition, storm water runoff, municipal and industrial discharges, and release from sediments (Guentzel *et al*. 1997; Gill *et al.* 1999; USEPA 2002). Inputs to coastal areas from river systems often account for the largest portion of the total load to the area (Cossa, *et al.* 1996; Chase *et al*. 2003, 2004). A large percentage of the total mercury in river systems is transported in the particulate phase as surface bound inorganic mercury, particularly if suspended particle concentrations are elevated (Stordahl and Gill 1996; Cossa *et al*. 1996, Mason *et al.* 1999).

6.4 POINT SOURCES - WASTEWATER DISCHARGES

Point source discharges of bioaccumulative chemicals like mercury may have particular local significance, apart from their contribution to the cumulative load. Point source discharges by their nature may create hot spots where observed elevated concentrations can have a potential impact on aquatic life, wildlife, and human health. In many cases elevated receiving water concentrations may be dictated solely by the mercury concentration in the effluent as opposed to the mercury delivered from air deposition. This will generally be true when comparing the near-field effects of effluent discharges relative to air sources.

Information on National Pollutant Discharge Elimination System (NPDES) permitted dischargers was obtained from the USEPA Permits Compliance System (PCS) database. There are a total of 61 major and 641 minor NPDES dischargers in the nine coastal basins and contributing watersheds of the study area, as summarized in Appendix C-1. The approximate locations of NPDES dischargers are shown by Figure 6.3 for information purposes only. A breakdown of major and minor permits by basin is shown in Table 6.1. Facilities located outside the adjacent coastal or contributing watersheds were not considered in this TMDL analysis. USEPA is establishing Hg TMDLs for six of the subsegments listed in Table 6.1 (010901, 021102, 042209, 070601, 110701, and 120806). Mercury TMDLs have already been established for subsegments 031201, 050901 and 061201.

Table 6.1 NPDES Major and Minor Permits

Coastal Segment	Segment Name	Minor Permits	Major Permits
010901	Atchafalaya Bay and Delta	121	2
021102	Barataria Basin Coastal Bays	82	5
031201	Calcasieu River Basin Coastal Bays	60	25
042209	Lake Pontchartrain Basin Coastal Bays	29	5
050901	Mermentau River Basin Coastal Bays	42	6
061201	Vermilion-Teche River Basin Coastal Bays	189	12
110701	Sabine River Basin Coastal Bays	1	0
120806	Terrebonne River Basin Coastal Bays	117	6
TOTAL		**641**	**61**

There are 29 facilities with discharge limitations for mercury located inside the coastal basins as listed in Table 6.2. The annual mercury loads from each of these permitted facilities were calculated using the effluent limitations from PCS. The loads in Table 6.2 are those in the established Calcasieu Estuary TMDL (USEPA 2002b) or in current permits. Where there is a discrepancy between what is in a current permit/PCS and the Calcasieu Estuary TMDL, the Calcasieu Estuary TMDL WLA was used.

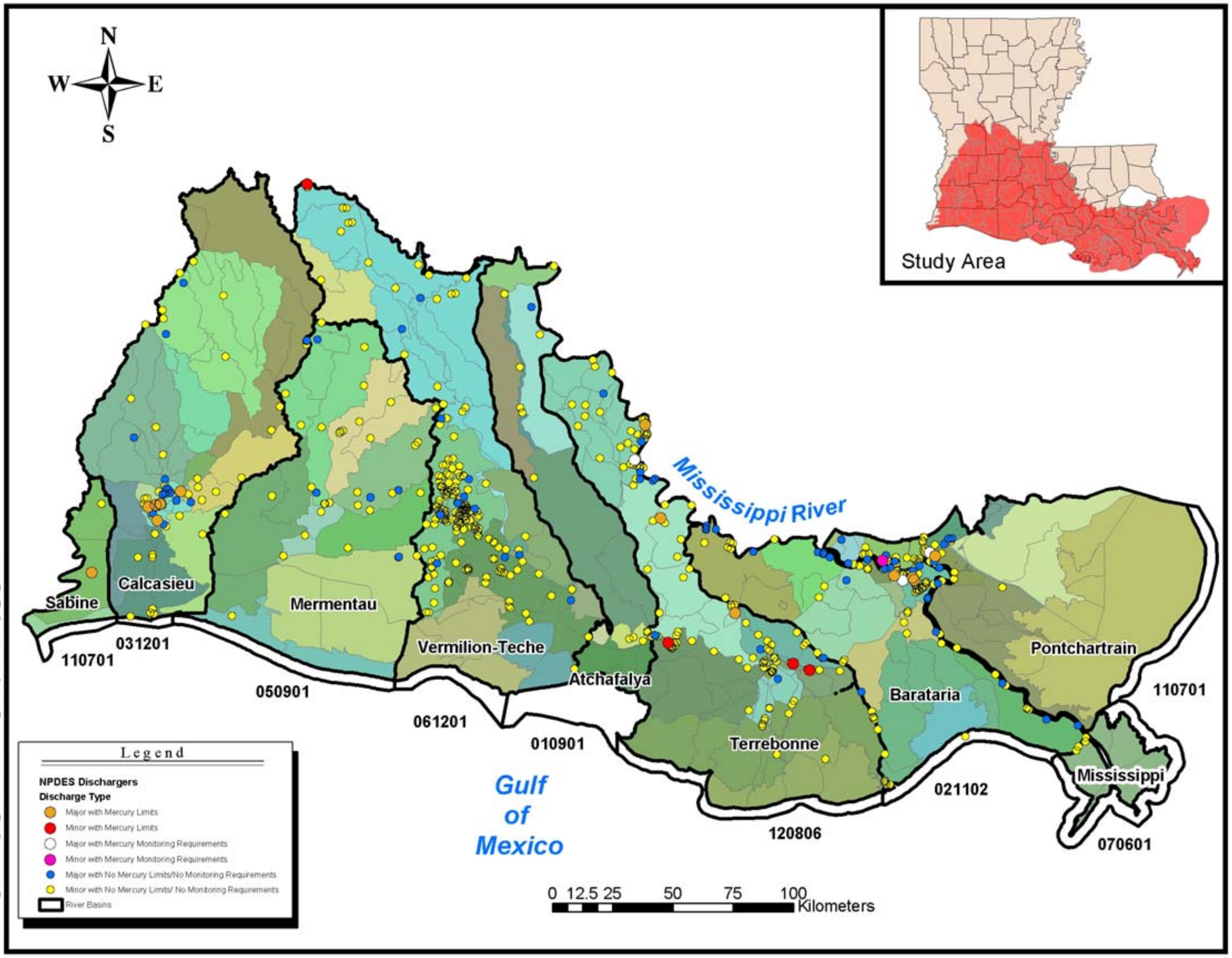
Mercury loads from municipal wastewater treatment plants (WWTP) were estimated as discussed below. Studies on municipal WWTPs indicate that trace levels of mercury can be present in discharges from these facilities. Municipal wastewater treatment facilities were assumed to discharge some Hg because Hg at low levels has been measured in WWTPs in the U.S. and Arkansas. The Association of Metropolitan Sewerage Agencies (AMSA) completed a study of 24 facilities in six states which showed a range of average mercury effluent

Table 6.2 NPDES Facilities with Mercury Limitations

Basin	Basin Name	NPDES No.	Permittee	Dly Avg lbs/day	Dly Max lbs/day	Dly Avg mg/L	Dly Max mg/L	Flow MGD	Hg Load lb/yr	Hg Load g/yr	NOTE
02	Barataria	LA0073954	Evans Cooperage	NA	NA	NA	0.002	0.014	0.083	38	1
		LA0038059	City of Westwego	0.0007	0.0017	NA	NA	2.770	0.256	116	4
03	Calcasieu	LA0054828	Chemical Waste Mgmt	NA	NA	NA	0.010	0.010	0.304	138	1,3
		LA0100099	Praxair	0.0000257	NA	NA	NA	0.5	0.009	4.3	4,5
		LA0053708	Air Liquide America	0.0000157	NA	NA	NA	0.5	0.006	2.6	4,5
		LA0080829	Louisiana Pigment Co	0.0107	NA	NA	NA	0.571	3.906	1,775	4,5
		LA0001333	WR Grace & Co	0.0219	NA	NA	NA	3.02	7.994	3,633	4,5
		LA0041025	Certainteed Corporaton	0.00055	NA	NA	NA	1.45	0.201	91	4,5
		LA0071382	Westlake Polymers	0.000841	NA	NA	NA	51.52	0.307	140	4,5
		LA0103004	Westlake Petrochemicals	0.00891	NA	NA	NA	0.8	3.252	1,478	4,5
		LA0003689	Basell USA	0.00896	NA	NA	NA	0.927	3.270	1,487	4,5
		LA0003824	Firestone	0.000665	NA	NA	NA	3.46	0.243	110	4,5
		LA0082511	Westlake Polymers	0.00127	NA	NA	NA	0.796	0.464	211	4,5
		LA0000761	PPG	0.00854	NA	NA	NA	2.91	3.117	1,417	4,5
		LA0003336	Sasol	0.0168	NA	NA	NA	4.51	6.132	2,787	4,5
		LA0005347	Lyondell	0.0316	NA	NA	NA	4.75	11.534	5,243	4,5
		LA0069850	Equistar Chemicals	0.000804	NA	NA	NA	9.15	0.293	133	4,5
		LA0087157	Westlake Styrene	0.00157	NA	NA	NA	42.16	0.573	260	4,5
		LA0003026	Conoco Lake Charles	0.0364	NA	NA	NA	5.4	13.286	6,039	4,5
		LA0005941	Citgo Petroleum	0.0781	NA	NA	NA	55.01	28.507	12,958	4,5
		LA0052370	Calcasieu Refining Co	0.0108	NA	NA	NA	0.075	3.942	1,792	4,5
		LA0101869	Cetco	0.00000027	NA	NA	NA	0.5	0.000	0.04	4,5
		LA0067083	City of Sulpher	0.0524	NA	NA	NA	5.03	19.126	8,694	4,5
		LA0036340	City of Lake Charles	0.00649	NA	NA	NA	3.89	2.369	1,077	4,5
		LA0108596	Denmar Enterprises	0.00000021	NA	NA	NA	0.5	0.000	0.03	4,5
		LA0105155	W-H Holdings	0.00000131	NA	NA	NA	0.5	0.000	0.22	4,5
12	Terrebonne	LA0068420	U.S. Liquids	NA	NA	0.000355	0.00843	0.010	0.011	4.9	2,3
		LA0089648	Bourg Dry Dock	NA	NA	0.00647	0.0172	0.010	0.197	0.09	2,3
		LA0105988	Earthlock Technologies	0.016	0.04	NA	0.00029	NA	5.840	2,655	4

1 - Hg Load (lbs/yr) = Dly Max Conc (mg/L) X Flow (MGD) X 8.34 X 365 days/yr
2 - Hg Load (lbs/yr) = Dly Avg Conc (mg/L) X Flow (MGD) X 8.34 X 365 days/yr
3 - Assumed Flowrate of 10,000 gallons/day
4 - Hg Load (lbs/yr) = Dly Avg Mass (lbs/day) X 365 days/yr
5 - Dly Avg Mass (lb/day) based on Total Maximum Daily Load for Toxics for Calcasieu Estuary May 2002

Figure 6.3 NPDES Facility Locations



concentrations of 3.1 ng/L – 9.0 ng/L, with maximum effluent concentrations ranging from 5.0 – 29.0 ng/L (AMSA 2002). The Arkansas Department of Environmental Quality conducted a monitoring study of five WWTPs in Arkansas using clean sampling procedures and ultra-clean trace level analysis and found average Hg concentrations of 15.0 ng/L in municipal discharges (USEPA 2002a).

Because effluent sampling for mercury in the past has been conducted without the benefit of newer clean techniques, little is known about the potential to discharge mercury for the majority of dischargers. USEPA believes it is appropriate to assume that discharges from the municipal WWTPs (SIC 4952) in these watersheds contain mercury levels equal to 12.0 ng/L.

All municipal WWTPs (SIC 4952) with a discharge greater than 100,000 gpd are being assigned an individual WLA. Their wasteload is based on their design flow and a target concentration of 12 ng/L Hg. In addition, a group allocation for dischargers with individual permits and general permits that may require a WLA in the future has also been included. This is designated as "unassigned wasteload" in Appendix C-2. The flow from general permits is not included in the estimate of the wasteload. The group allocation for all basins except the Sabine and Mississippi River Basins was based on the total flow for dischargers not given a specific WLA and a target concentration of 12 ng/L Hg. Currently only one facility discharges into the Sabine River Basin, and USEPA has chosen to give a group allocation equivalent to the WLA being established for that facility. The WLA for each basin is calculated as:

$WLA = \Sigma A + \Sigma B + C$

A = WLA based on permit limitation

B = WLA for SIC 4952 facilities based on 12 ng/L Hg and discharge flow rate

$C = \text{Group WLA} = 0.5*(\Sigma A + \Sigma B)$

Appendix C includes a list of the NPDES dischargers in each coastal basin and an estimate of the mercury loading from each facility as appropriate. There are two parts to Appendix C. Appendix C-1 lists the permitted facilities by basin along with flow rates. Appendix C-2 lists only those facilities for which wasteloads are being established in these TMDLs. Table 6.3, which is derived from Appendix C-2, is a summary of the point source mercury load estimates for each coastal basin and contributing watershed. The unassigned wasteload allocation is intended to accomodate those point source discharges that are not accounted for in the individual WLAs. When permits are issued for such sources, the permitting authority will need to evaluate whether the point source discharge will cause or contribute to a localized exceedance of the applicable water quality standard and determine the appropriate permit limit accordingly. This calculation will vary depending on the specific water at issue.

Table 6.3 Mercury Point Source Load Estimates

Basin No.	Basin Name	Hg Load (g/yr)
01	Atchafalaya	174
02	Barataria	324
04	Lake Pontchartrain	527
11	Sabine	57
12	Terrebonne	985

USEPA determined that no reasonable probability exists for dischargers below 0.1 million gpd (mgd)to be a significant contributor of mercury, and these facilities are not subject to any further permit requirements or load reductions for mercury based on this TMDL. This determination is based on information evaluated when USEPA developed the new NPDES permit application Forms 2A and 2S and upon LDEQ's experience in permitting dischargers under general permits.

When the USEPA developed the new NPDES permit application Forms 2A and 2S, the amount of information required for minor facilities was limited to specific sections because those facilities are unlikely to discharge toxic pollutants, including mercury, in amounts that would impact state WQSs. The new permit application forms applied not only to Publicly Owned Treatment Works (POTW), but also to facilities similar to POTWs but which do not meet the regulatory definition of "publicly owned treatment works" (like private domestics, or similar facilities on Federal property). These forms became effective December 1, 1999, after publication of the final rule on August 4, 1999, (64 FR 42433). Supporting information for this decision was published as "Evaluation of the Presence of Priority Pollutants in the Discharges of Minor POTW's," June 1996, and was sent to all state NPDES coordinators by USEPA Headquarters.

In the study, USEPA collected and evaluated data on the types and quantities of toxic pollutants discharged by minor POTWs. The study consisted of a query of the USEPA PCS database, an evaluation of minor POTW data provided by State agencies, and on-site monitoring for selected toxics at 86 minor facilities across the nation. PCS and the study showed that minor POTWs below 0.1 mgd serve very small communities and contribute a small amount of flow, generally with no industrial users. Mercury was not detected at any of the facilities sampled in the study. Effluent pollutant concentration data were directly compared to water quality criteria and did not consider other site-specific factors such as receiving stream flow, hardness, temperature, turbidity, salinity, *etc*. This was considered an overly conservative approach by the study, but used as such to illustrate the extremely low reasonable probability these facilities had to violate state WQSs.

Additionally, discharges from facilities permitted under Louisiana Pollution Discharge Elimination System (LPDES) general permits typically consist of low volume flows that are typically intermittent in nature, and applicable to very specific types of facilities allowing for very limited types of discharges. LDEQ's experience in permitting dischargers under LPDES general permits also identified no quantifiable degradation to the receiving water bodies from discharges under previously issued general permits. Based on LDEQ's experience permitting small dischargers and the nature of the information evaluated when USEPA developed permit application Forms 2A and 2S, the determination that facilities below 0.1 mgd are not expected to be significant contributors of mercury loads to the receiving streams is supported, and these facilities are not subject to any further requirements based on this TMDL unless otherwise noted.

Therefore, the proposed TMDLs will verify loadings from those point source dischargers known to be discharging Hg or are likely to be discharging Hg, although every discharger is assigned either an individual WLA or is covered by the group WLA. USEPA expects LDEQ to systematically identify those dischargers that are significant sources of Hg.

6.5 NONPOINT SOURCES OF MERCURY CONTAMINATION

6.5.1 Mississippi River Loading

The Mississippi River represents a potentially significant source of mercury to the Coastal Bays and Gulf Waters of Louisiana because of the large drainage area and massive flow rate. The mercury load from the Mississippi River is the sum of the dissolved mercury in the water column and the total mercury on suspended solids. The mercury load is estimated by assuming that the mercury concentration of the total suspended solids (TSS) is in equilibrium with the river bottom sediments as summarized in Table 6.4. The values in Table 6.4 are derived from Appendix D which includes water column mercury measurements, mercury in sediment, and TSS data from LDEQ collected between 2001 and 2004. Appendix D also includes annual average flow data from the USGS gage station 7373291 for the Mississippi River.

Table 6.4 Mississippi River Parameters

FLOW (FT^3/SEC)	HG IN WATER (UG/L)	HG IN SEDIMENT (MG/KG)	TSS (MG/L)
470,435	0.00114	0.0445	85.7

The total mercury load from the Mississippi River is estimated to be 2,117,000 grams per year as shown by the following calculations:

$$(470{,}435\ ft^3/sec)(28.316\ L/ft^3)(3600\ sec/hr)(24\ hr/day)(365\ days/yr) = 4.2 \times 10^{14}\ L/yr$$

$$(0.00114\ ug/L)(1\ kg/10^9\ ug)(4.2 \times 10^{14}\ L/yr) = 479\ kg/yr\text{- Hg in Water}$$

$$(85.7\ mg\ TSS/L)(4.2 \times 10^{14}\ L/yr)(1\ kg/10^6\ mg)(0.0455\ mg\ Hg/kg\ TSS)(1\ kg/10^6\ mg) = 1638\ kg/yr – \text{Hg in Sediment}$$

Total Hg = Hg in Water + Hg in Sediment

Total Mercury = 479 kg/yr + 1638 kg/yr = (2117 kg/yr) x (1,000 g/kg) =2,117,000 g/yr

6.5.2 Air Emissions

It is a well known fact that a major source of nonpoint source loads of mercury in the environment is from air emissions. A series of four monitors in Louisiana have been collecting mercury concentration and wet deposition data since 1998 as part of the MDN program as previously discussed in Subsection 5.4. These data confirm air emissions as a major source of mercury in the environment. MDN mercury data have been used in Louisiana to estimate nonpoint source loads of mercury and to establish TMDLs in other watersheds (USEPA 2003). The USEPA used an air modeling approach to support this TMDL project to predict mercury concentrations of both wet and dry mercury deposition.

The model used was REMSAD, Version 7. A report detailing the approach and outputs of REMSAD for the Louisiana coast entitled *REMSAD Air Deposition Modeling in Support of TMDL Development for Southern Louisiana* was finalized by USEPA Region 6 in August 2004. The model was enhanced to better account for the complex atmospheric chemistry of mercury species. The REMSAD model run for this project was set up using a

4 kilometer (km) grid to provide better resolution in the southern part of Louisiana (USEPA 2004). The simulated results are compared to the observed MDN data in Table 6.5.

Table 6.5 REMSAD Data Comparison

MDN SITE	SIMULATED (G/KM^2)	1999 ACTUAL (G/KM^2)	2000 ACTUAL (G/KM^2)	2001 ACTUAL (G/KM^2)	2002 ACTUAL (G/KM^2)
LA05	23.65	13.71	11.35	17.67	12.02
LA10	9.30	13.22	13.10	18.39	14.23
LA23	15.27	NA	NA	16.87	13.21
LA28	22.33	13.36	11.23	14.47	13.48

The REMSAD modeling report indicates that simulated values are high compared to the average observed values, and cautions the user to take this into consideration when using the data (USEPA 2004). One explanation for the high simulated values is that 1998 meteorological data are used along with 2001 TRI and TEDI data. Nevertheless, predicted values are on the same order of magnitude as the observed values and will be used to estimate nonpoint source loads for this TMDL project because of the greater resolution it affords across multiple sub-watersheds.

REMSAD simulates both wet and dry deposition of mercury with wet deposition occurring as a result of precipitation scavenging, and dry deposition being based on land use characteristics and meteorological parameters (USEPA 2004). Table 6.6 summarizes the REMSAD model results for both wet and dry deposition. It is important to note that the geographic regions represented by the REMSAD simulations, called Coastal and Near Coastal areas in the REMSAD report, are somewhat different than the nine coastal basins used to develop the TMDLs in this report.

Table 6.6 REMSAD Model Results

		Near Coastal		Coastal	
		Dry %	Wet %	Dry %	Wet %
Lower Calcasieu	Boundary Condition	80	97	85	98
	Other States	11	3	12	2
	Tagged Sources	9	< 1	3	0
Vermilion	Boundary Condition	76	98	82	98
	Other States	9	2	11	2
	Tagged Sources	15	< 1	7	< 1
West Central LA	Boundary Condition	72	98	83	98
	Other States	9	2	10	2
	Tagged Sources	20	< 1	7	< 1
Mermentau	Boundary Condition	85	98	86	98
	Other States	10	2	10	2
	Tagged Sources	5	< 1	4	< 1

Table 6.6 REMSAD Model Results (continued)

		Near Coastal		Coastal	
		Dry %	Wet %	Dry %	Wet %
Bayou Teche	Boundary Condition	74	97	79	97
	Other States	9	3	10	3
	Tagged Sources	17	< 1	11	< 1
East Central LA	Boundary Condition	31	88	81	96
	Other States	4	2	12	3
	Tagged Sources	65	10	7	1
East LA Coast	Boundary Condition	65	95	80	97
	Other States	9	2	14	3
	Tagged Sources	26	3	6	< 1
Lake Maurepas	Boundary Condition	50	90	29	73
	Other States	7	4	5	2
	Tagged Sources	43	6	66	25
Lake Pontchartrain	Boundary Condition	73	91	68	92
	Other States	13	6	12	4
	Tagged Sources	14	3	20	4

The above table shows that nearly all the **wet** deposition for both the coastal and near coastal areas is attributed to boundary conditions (global sources) and mercury emissions from other states. However, emissions from tagged sources within Louisiana accounted for 3 percent – 66 percent of the **dry** deposition for the coastal cataloging unit, and for 5 percent – 65 percent of the **dry** deposition for the near coastal cataloging unit. The tagged sources were facilities in Louisiana that reported TRI or TEDI mercury emissions such as coal-fired power plants, incinerators, and chemical plants. Figures 6.4 and 6.5 show the wet and dry mercury deposition from the REMSAD model averaged across each subsegment in the study area. Figure 6.5 illustrates the dry deposition impact of some of these tagged sources in the Baton Rouge, New Orleans, and Lake Charles areas. Output from the REMSAD model includes a complete breakdown of the contribution of each of 10 tagged sources (USEPA 2004).

6.5.3 Watershed Mercury Loading

While various analyses for watershed mercury loadings are possible at various levels of complexity, the limited amount of data available for the Coastal Bays and Gulf Waters of Louisiana precluded use of detailed hydrodynamic modeling. As an alternative method, Hg contributions to the Coastal Bays and Gulf Waters of Louisiana from both adjacent watersheds and upstream contributing watersheds were calculated based on an annual mass balance approach. A linear relationship is assumed to exist between the body burden of Hg in king mackerel fish tissue and the Hg loading to each 303(d)-listed subsegment. Output from the REMSAD model was used as input to the Pollutant Load (PLOAD) application of the BASINS Version 3 (USEPA 2001a) model to estimate nonpoint source mercury loads as discussed below. This approach is similar to the method used in previously approved TMDLs in Louisiana involving fish consumption advisories for mercury (USEPA 2003).

The main component of the BASINS system utilized was the PLOAD model. PLOAD is a simplified, geographic information system (GIS)-based model intended to calculate pollutant loads for watersheds. PLOAD estimates nonpoint source loads on an annual average basis using either the export coefficient or USEPA's Simple Method approach.

The PLOAD model was employed to provide estimates of both the average annual runoff and eroded sediment TSS loads from each of the subsegments that comprise the six coastal basins considered. Annual average wet and dry mercury deposition values obtained from the REMSAD outputs were then used to estimate the mass of mercury contained in the runoff in both the water column and associated transported particulates. The hydrologic and TSS loading coefficients required by the model were developed from values available in the literature. The PLOAD model varies the loading coefficients by land use provided with GIS coverage. Appendix E presents results of the PLOAD modeling for each 303(d)-listed subsegment for both annual average runoff volumes and annual average TSS loads. Figures 3.3 and 3.5 illustrate the spatial distribution of rainfall and land use, respectively, employed in the PLOAD modeling.

The predominant source of mercury in coastal Louisiana watersheds is atmospheric deposition. The REMSAD Version 7 is a three-dimensional grid model designed to calculate concentrations of both inert and chemically reactive pollutants by simulating the physical and chemical processes in the atmosphere that affect pollutant concentrations. REMSAD provides estimates of the concentrations and deposition of the simulated pollutants at each grid location in the modeling domain. REMSAD model results were imported into the GIS developed for this project. The subsegments within each of the coastal basins were used to clip the corresponding cells derived from the 4 km grid. The wet and dry deposition values for each grid cell within a subsegment were then averaged independently to provide the basis for loading estimates from PLOAD. Figure 6.4 illustrates the simulated annual average wet deposition of Hg in grams per square km for the study area, while Figure 6.5 depicts the same information for annual average dry deposition.

While the linear relationship between fish tissue concentration of mercury and mercury loading to the 303(d)-listed subsegments is a necessary assumption when using a water quality target for fish consumption advisory based on narrative criteria, there are a number of other variables that must be acknowledged when developing nonpoint source loading estimates for bioaccumulative pollutants like mercury. Toxic pollutants such as mercury attach to sediment particles creating complex fate and transport and bioavailability characteristics of toxics. Mercury attached to sediment particles may settle out of the water column or may be resuspended into the water column and transported downstream. While the amount of mercury attached to sediment particles in the coastal subsegments can be estimated as the difference between the total and dissolved form of Hg, the density of the particles to which the pollutant is attached is unknown (USEPA 2002b). There are insufficient data available to conduct an in-depth simulation of the fate and transport of mercury in the water column or sediment resuspension of the Coastal Bays and Gulf Waters of Louisiana. Given these complexities and uncertainties, USEPA chose for these TMDLs to base its calculations of nonpoint source mercury loading to the 303(d)-listed subsegments on the conservative assumption that 100 percent of the nonpoint source loads are transported to the coastal basins.

To calculate the mercury load transported to the receiving waters from runoff in both the adjacent watersheds and the upstream contributing watersheds, the assumption was made that runoff contains the same mercury concentration as the originating rainfall. This option also assumes that 100 percent of the rainfall runoff (dissolved mercury load) from the entire coastal basin (both contributing and adjacent watersheds) is transported to the 303(d)-listed coastal subsegments. USEPA is using 100 percent because it is the most conservative option and there is a lack of available data to do fate and transport modeling. (See Figure 3.2 for the delineation of contributing and adjacent watersheds.) The results calculated using this conservative assumption are shown in Appendix E, Table E-1. Figure 6.6 displays the average estimated mercury load for each subwatershed from rainfall runoff (dissolved mercury load).

To estimate the mercury loadings associated with sediments eroded from each watershed, average sediment mercury concentrations for various waterbodies in the study area were utilized in conjunction with TSS estimates from the PLOAD model. The results calculated using the conservative assumption that 100 percent of the mercury associated with soil erosion (particulate mercury load) from the entire coastal basin (both contributing and adjacent watersheds) is transported to the 303(d)-listed coastal subsegments are shown in Appendix E, Table E-1. Figure 6.7 displays the estimated average mercury load for each subwatershed from soil erosion (particulate mercury load) in the overall study area. Figure 6.8 displays the combined annual average of dissolved and particulate mercury load based on the assumption that 100 percent of the mercury deposition is transported to the 303(d)-listed coastal subsegments in the study area. Table 6.7 summarizes the total estimated nonpoint source loads for all basins covered in the study area.

Table 6.7 Estimated Mercury Loading from Nonpoint Sources

Basin	Soil Erosion Load (g/r)	Runoff Load (g/yr)
Atchafalaya	43,489	12,140
Barataria	79,326	15,264
Calcasieu	60,539	26,960
Pontchartrain	44,157	8,031
Mermentau	80,844	30,586
Vermilion-Teche	51,841	28,140
Mississippi	8,832	1,746
Sabine	17,241	2,837
Terrebonne	83,483	21,837
Total	**479,753**	**147,542**

Figure 6.4 Annual Average Wet Deposition – Mercury

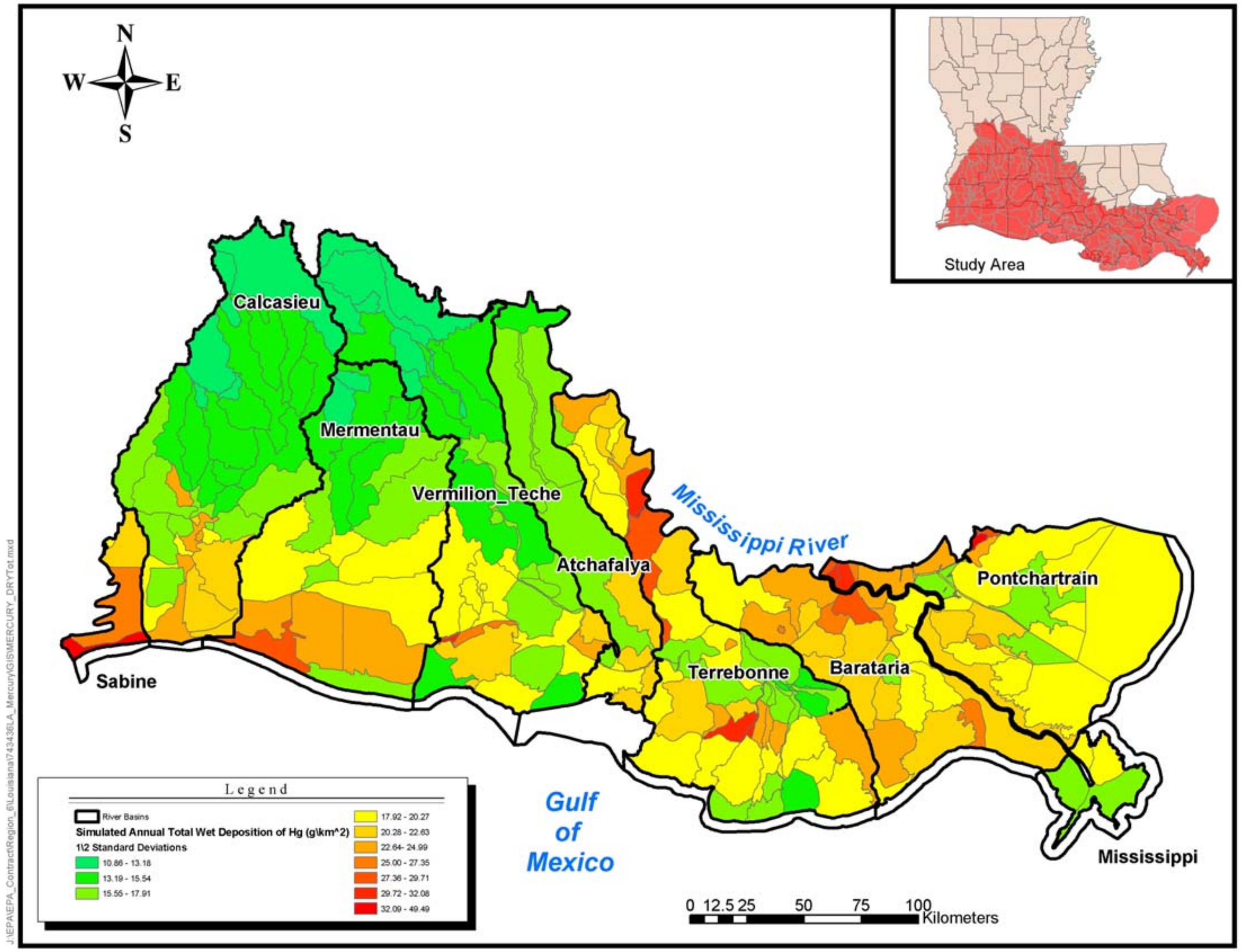


Figure 6.5 Annual Average Dry Deposition – Mercury

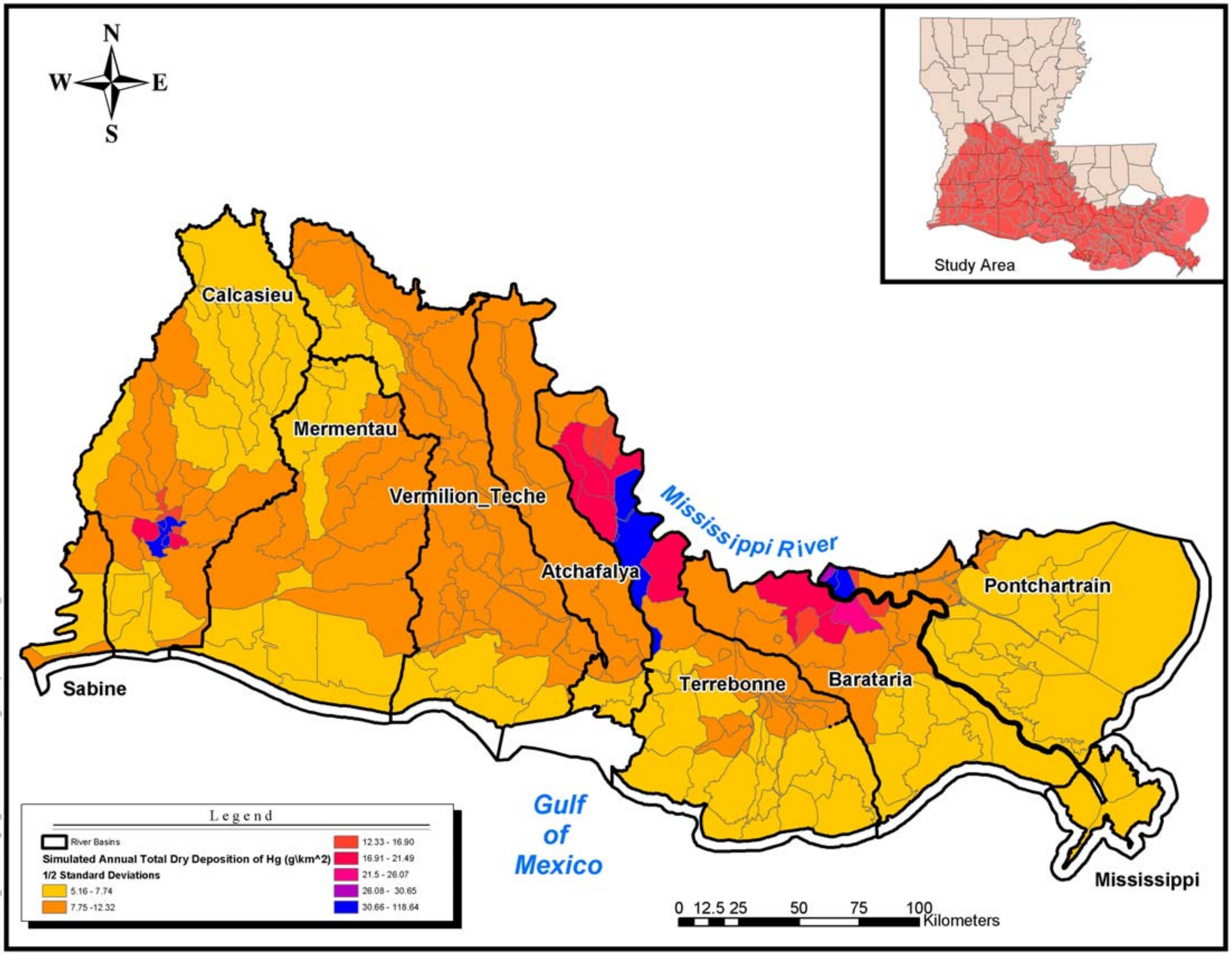


Figure 6.6 Total Annual Average Dissolved Mercury Load, g/yr

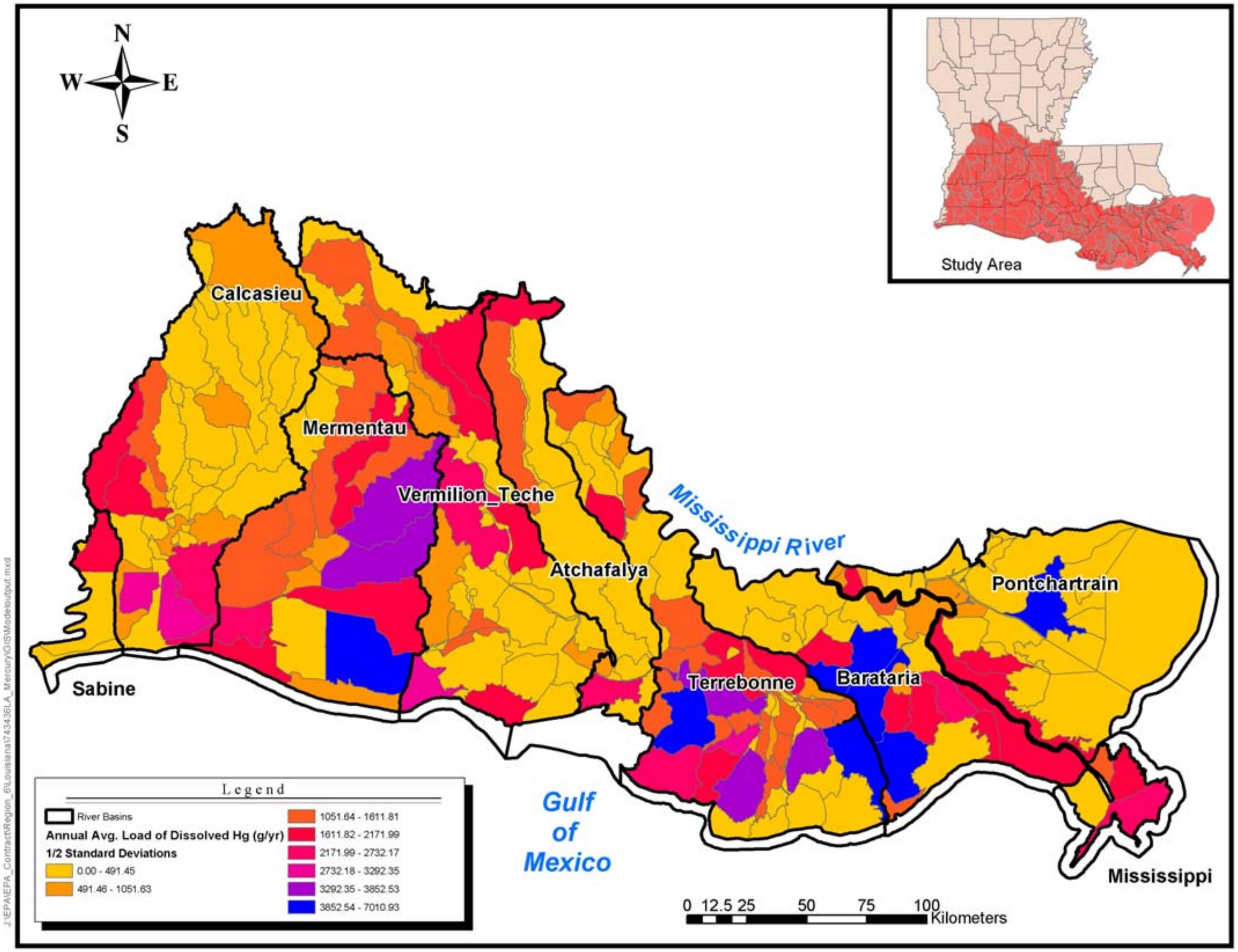


Figure 6.7 Total Annual Average Particulate Mercury Load, g/yr

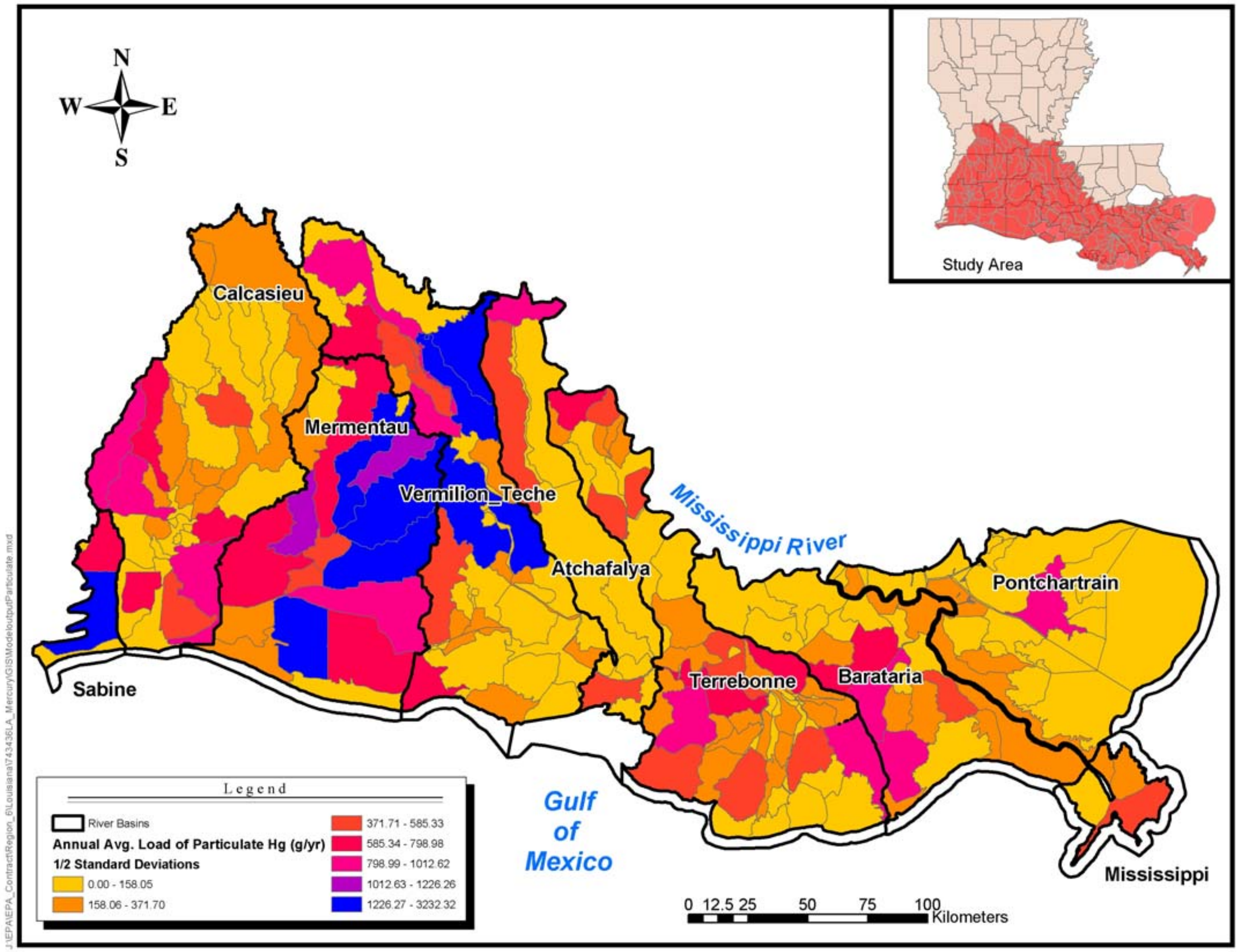
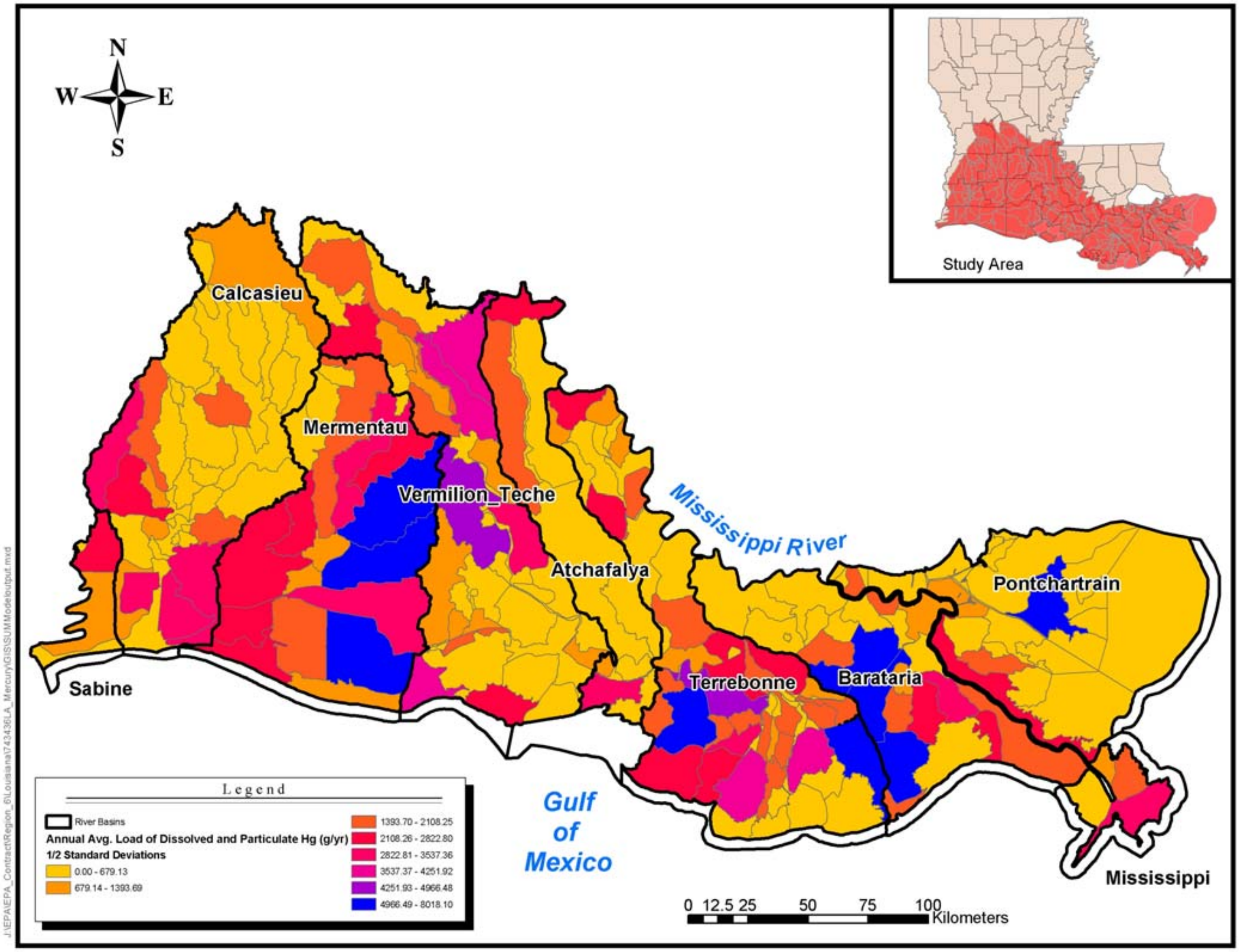


Figure 6.8 Total Annual Average Loading of Dissolved and Particulate Mercury, g/yr



6.5.4 Miscellaneous Mercury Sources

The LDEQ estimates there are 25,000–30,000 natural gas metering stations located throughout Louisiana. Many of these metering stations have component parts containing mercury, which is reasonably expected to have been released to the environment over the past decades. To date, approximately 5,000 sites have been checked for mercury contamination and the 2,500 that were contaminated have been cleaned (LDEQ 2003). While these gas metering stations are a source of mercury to the environment, contamination is localized to soil in the immediate vicinity of the station. Mercury loads from these facilities are not included in this analysis because it is not possible to accurately quantify potential impacts to the receiving waters.

Numerous studies have been conducted to determine the concentration of mercury in sediments and any impacts to the benthic organisms in the vicinity of offshore drilling rigs (Neff 2002). Barite is a commonly used drilling fluid which is discharged from rigs during the drilling process. The USEPA currently limits the concentration of mercury in barite to 1.0 mg/kg; however, higher levels were used historically. One study measured the Near Field (0-100 m), the Mid Field (100-250 m), and the Far Field (3 km) mercury concentrations in sediment at six offshore platforms (Trefry 2003). Results of the study are summarized in Table 6.8.

Table 6.8 Offshore Platform Average Sediment Concentrations (mg/kg)

SITE	NEAR FIELD	MID FIELD	FAR FIELD
MP299	0.058	0.059	0.061
MP288	0.052	0.054	0.029
EI346	0.185	0.072	0.047
MC469	0.096	0.078	0.071
EW963	0.180	0.106	0.071
GC112	0.248	0.101	0.079
Average	0.137	0.078	0.060

Another study of barite drilling fluid concluded that mercury is present in the material as a metal sulfide with very low solubility and that the chemical conditions in marine sediments do not promote conversion of total mercury to methylmercury (Trefry 2003a). Some impacts to benthic organisms have been documented, but they are generally localized and within 100 meters (m) of the offshore platforms (Montagna 1996).

SECTION 7
TMDL CALCULATIONS

7.1 CURRENT LOAD EVALUATION

Based on the assessment of mercury sources summarized in Section 6, the current load can be derived from the sum of all point and nonpoint sources. This is determined as:

> Current loading = loading from the NPDES dischargers (point source) + loading from Mississippi River (nonpoint source) + loading from contributing and adjacent watersheds (nonpoint source which includes atmospheric deposition)

Classification of mercury loading from the Mississippi River as a nonpoint source is necessary since it was beyond the scope of these TMDLs to differentiate point sources from nonpoint sources of mercury for a geographic area covering almost two-thirds of the continental United States. The calculation of current loading indicates that rainfall runoff and soil erosion are the major contributors of the total mercury load to each 303(d)-listed coastal subsegment and this is assumed to be the case for the Mississippi River. The fate and transport of mercury from water and sediments to fish tissue is complex, and modeling of mercury once it is in the waterbody was not attempted since there is not enough site-specific data to calibrate and verify a model. Because of the vast geographic area covered and the lack of data to employ complex sediment transport models, USEPA assumed that 100 percent of the dissolved and particulate mercury loads generated by the contributing and adjacent watersheds reach the 303(d)-listed coastal subsegments where they are available for uptake, bioaccumulation, and biomagnification by fish. Table 7.1 shows the mercury loads based on this 100 percent assumption.

Table 7.1 Summary of Estimated Current Mercury Loading

Coastal Segment	Segment Name	Point Source Hg Load (g/yr)	Point Source Basin Load %	Nonpoint Source Hg Load (g/yr)	Nonpoint Source Basin Load %	Total Hg Load (g/yr)
010901	Atchafalaya Bay and Delta	174	0.3	55,629	99.7	55,803
021102	Barataria Basin Coastal Bays	324	0.3	94,590	99.7	94,914
042209	Lake Pontchartrain Basin Coastal Bays	527	1.0	52,188	99.0	52,715
070601	Mississippi River Basin Coastal Bays*	0	0.0	2,127,578	100.0	2,127,578
110701	Sabine River Basin Coastal Bays	57	0.3	20,077	99.7	20,134
120806	Terrebonne River Basin Coastal Bays	985	0.8	115,321	99.2	116,306

*Total Hg Load = (PLOAD Dissolved Hg + Mississippi Hg in Water)
+ (PLOAD particulates + Mississippi Hg in sediment)
(8,832 g/yr + 479,000 g/yr) + (1,746 g/yr + 1,638,000 g/yr)
= 2,127,578 g/yr

7.2 LOAD REDUCTION GOAL

USEPA selected the average tissue concentration of mercury from 74 king mackerel collected between 1996 and 2004 to best represent the concentration throughout the Coastal Bays and Gulf Waters of Louisiana. This average concentration for Hg in king mackerel, taken from Appendix B, is 1.2129 mg/kg as shown in Table 7.2.

Table 7.2 Mercury in King Mackerel Tissue (mg/kg)

Min	Avg	Max	n
0.1334	1.2129	5.9040	74

The mercury concentration in fish tissue must be reduced by 59 percent to achieve the safe tissue concentration of 0.5 mg/kg. Therefore, the mercury load to the watershed must also be reduced by 59 percent based on the assumption that there is a linear relationship between the mercury load and mercury concentration in fish tissue, as discussed in Section 4.4. The percent reduction calculation is shown below.

Percent Reduction = [(1.2129 mg/kg - 0.50 mg/kg) / (1.2129 mg/kg)] X 100 = 59%

The overall pollutant load reduction required is 1,455,796 grams per year (g/yr) as shown by the calculations below.

Load Reduction = (2,467,450 g/yr)(59%/100) = 1,455,796 g/yr

7.3 TMDL DETERMINATION

The following equation was used to define the allowable loading of mercury, or the TMDL, to meet the endpoint.

TMDL = Current Estimated Pollutant Loading – Pollutant Load Reduction Necessary

The TMDLs for each 303(d)-listed coastal subsegment are shown in Table 7.3.

Table 7.3 Load Allocations for Coastal Basins

Coastal Segment	Segment Name	Point Source Hg Load (g/yr)	NPS Hg Load (g/yr)	Total Hg Load (g/yr)	Hg Load Reduction (g/yr)	NPS Load Allocation (g/yr)
010901	Atchafalaya Bay and Delta	174	55,629	55,803	32,924	22,705
021102	Barataria Basin Coastal Bays	324	94,590	94,914	56,000	38,591
042209	Lake Pontchartrain Basin Coastal Bays	527	52,188	52,715	31,102	21,086
070601	Mississippi River Basin Coastal Bays	0	2,127,578	2,127,578	1,255,271	872,307
110701	Sabine River Basin Coastal Bays	57	20,077	20,134	11,879	8,198
120806	Terrebonne River Basin Coastal Bays	985	115,321	116,306	68,620	46,700

NPS Non Point Source

7.4 MARGIN OF SAFETY

The CWA requires that TMDLs take into consideration an MOS. USEPA and LDEQ guidance allow for the use of implicit or explicit expressions of the MOS or both (Waldon 2000). When conservative assumptions are used in development of the TMDL, or conservative factors are used in the calculations, the MOS is implicit. When a percentage of the load is factored into the TMDL calculation as an MOS, the MOS is explicit. The following conservative assumptions were made providing an implicit MOS; an explicit MOS was not considered appropriate.

- Calculations for mercury concentrations associated with TSS loading from soil erosion to the water column assume no loss of mercury from any mechanism during transport.

- Conservative assumptions were used when selecting concentration values for mercury species (element, divalent gas, and divalent particulate Hg) to represent global background levels of mercury in REMSAD (USEPA 2004).
- Mercury loading to the 303(d)-listed subsegment is considered 100 percent available for uptake, bioaccumulation, and biomagnification by fish.
- There is an implicit MOS as a result of using a tissue methylmercury endpoint when fish tissue analysis is based on total mercury measurements.
- For facilities with mercury permit limits, the permit limits were used to establish the mercury loads from these facilities. The actual discharge of mercury from these facilities is probably less.
- For municipal WWTPs (SIC 4952), with flows greater than 100,000 gpd, it was assumed that 12.0 ng/L of mercury was discharged from each facility. The actual discharge of mercury from these facilities may be less than this value.
- The REMSAD deposition model overestimates the actual input based on a comparison to available MDN data.

7.5 TOTAL MAXIMUM DAILY LOAD

The TMDLs outlined in Table 7.4 provides the WLA (point sources), LA (nonpoint sources), and MOS (implicit) as required for each 303(d)-listed coastal subsegment. As previously indicated, a 59 percent reduction in mercury loading is necessary to achieve the endpoint of 0.5 mg/kg concentration in fish tissue.

Table 7.4 TMDL Summary

Coastal Segment	Segment Name	TMDL (g/yr)	WLA (g/yr)	LA (g/yr)	MOS (g/yr)
010901	Atchafalaya Bay and Delta	22,879	**174**	**22,705**	**0**
021102	Barataria Basin Coastal Bays	38,915	**324**	**38,591**	**0**
042209	Lake Pontchartrain Basin Coastal Bays	21,613	**527**	**21,086**	**0**
070601	Mississippi River Basin Coastal Bays	872,307	*****	**872,307**	**0**
110701	Sabine River Basin Coastal Bays	8,255	**57**	**8,198**	**0**
120806	Terrebonne River Basin Coastal Bays	47,685	**985**	**46,700**	**0**

* EPA notes that the load allocation for the Mississippi River basin accounts for the mercury load from upstream sources in the basin (including point and nonpoint sources). Because of the large geographic scope of the basin and the difficulty in identifying specific sources, EPA has not allocated specific waste loads to point sources in the Mississippi River basin upstream of the TMDL area. However, EPA understands that Louisiana will issue NPDES permits for sources in the upstream area within the State's jurisdiction, and in doing so will evaluate whether the point source discharge will cause or contribute to a localized exceedance of the applicable water quality standard and determine the appropriate permit limit accordingly. Thus, the inability to identify and assign specific WLAs to sources in areas outside the basins subject to the TMDL does not mean that such sources will be unable to obtain NPDES permits.

USEPA has estimated wasteloads for point source dischargers as discussed in Subsection 6.4. In summary, these wasteloads are based on mercury limits in existing permits, an assumption of 12 ng/L mercury in the discharge from POTWs with flows greater than 100,000 gpd, and an unassigned wasteload has been estimated for each coastal basin.

Since USEPA expects that a combination of ongoing and future activities under the Clean Air will achieve reductions in the air deposition of mercury that will enable progress toward achievement of water quality standards. Since the point source contributions are 1% or less for each basin and most point sources have not tested their effluent with method 1631, USEPA is not requiring point source reductions at this time. The WLAs established for these TMDLs are set at the existing estimated wasteloads for each basin. Thus, a 59 percent reduction in nonpoint source mercury loads is required.

Nonpoint source loading to each subsegment emanates from local sources of atmospheric deposition and global/national sources of atmospheric deposition. The REMSAD report, *REMSAD Air Deposition Modeling in Support of TMDL Development for Southern Louisiana*, provides the detailed results to differentiate atmospheric deposition from local, national, and global emission sources.

USEPA expects these TMDLs will be implemented as follows:

- Non-sanitary point source dischargers eligible for general permits or individual permits that discharge less than 100,000 gpd and do not have a Hg limitation or monitoring requirement in their permit are considered to be unlikely or minimal sources of Hg and will not be required to monitor for Hg or be given permit limitations for Hg.
- Non-Sanitary point source dischargers greater than 100,000 gpd that report discharges of Hg through the TRI or under their existing LPDES permit monitoring requirements, will be required to monitor for Hg in their effluent using clean techniques at the time of application. If Hg is detected above the target concentration of 12 ng/L, they will be required to develop a mercury minimization plan for their facility. If reasonable potential exists, the discharge will be screened in accordance with the currently approved Permitting Guidance Document for Implementing Louisiana Surface Water Quality Standards.
- Sanitary WWTPs with discharges greater than 100,000 gpd and less than 1.0 mgd that have identified potential sources of Hg through the pre-treatment program will be required to monitor for Hg in their effluent using clean techniques at the time of application, and if Hg is detected above 12 ng/l they will be required to develop a Hg minimization plan for their facility and all sources discharging into the municipal treatment plant. If reasonable potential exists, the discharge will be screened in accordance with the currently approved Permitting Guidance Document for Implementing Louisiana Surface Water Quality Standards.
- Sanitary WWTPs with discharges greater than 1.0 mgd will be required to monitor for Hg in their effluent using clean techniques at the time of application. If Hg is detected above 12 ng/L, they will be required to develop a mercury minimization plan for their facility and all sources discharging into the treatment plan. If reasonable potential exists, the discharge will be screened in accordance with the currently approved Permitting Guidance Document for Implementing Louisiana Surface Water Quality Standards.
- All point sources greater than 100,000 gpd discharging into a waterbody that has a fish consumption advisory for Hg will be required to monitor for Hg in their effluent using

clean techniques at the time of application. If Hg is detected above 12 ng/L, then they will be required to develop a mercury minimization plan for their facility. If reasonable potential exists, the discharge will be screened in accordance with the currently approved Permitting Guidance Document for Implementing Louisiana Surface Water Quality Standards.

7.6 SEASONAL VARIATION

Federal regulations [40 CFR §130.7(c)(1)] require that TMDLs take into consideration seasonal variability in applicable standards. These TMDLs are presented as annual average loads because Hg bioaccumulates over the life of the fish and the resulting risk to human health from fish consumption cannot be effectively quantified on a daily or weekly basis. While there are various seasonal characteristics that affect mercury concentrations in the Louisiana coastal zone such as wet deposition being greater in the winter and spring seasons and methylation of mercury being more active during the summer, daily or weekly inputs are less meaningful than total annual loads over many years. Summer is also the period when large areas of the Gulf of Mexico west of the Mississippi River experience hypoxia (low oxygen conditions) (Rabalais, *et al*. 1997), which is conducive to methylation. Based on the enhanced methylation and higher predator feeding rates during this period, mercury bioaccumulation is expected to be greatest during the summer (USEPA 2002). However, given the long depuration times for fish and relatively mild winters in coastal Louisiana, seasonal changes in fish tissue mercury body burden are expected to be relatively small. Inherent variability of mercury concentrations between individual fish of the same and/or different size categories is expected to be greater than seasonal variability (USEPA 2002).

SECTION 8
ONGOING AND FUTURE POLLUTANT LOADING REDUCTIONS

Table 7.1 shows that current mercury loadings throughout the project study area are primarily from nonpoint sources. As discussed in Subsection 7.2 of this report, a 59 percent reduction in mercury loading is necessary to achieve the applicable endpoint of 0.5 mg/kg in fish tissue.

8.1 AIR AND WASTE

Based on the December 1997 Mercury Study Report to Congress (USEPA 1997), USEPA estimates that 60 percent of the total mercury deposited in U.S. waterbodies which contaminates fish comes from domestic anthropogenic air emission sources. USEPA and LDEQ have taken key steps nationally and regionally toward reducing mercury emissions and environmental and human health risks associated with mercury exposure. State and federal mercury air emission rules which apply to facilities in Louisiana (LAC 33: III. Chapter 51). USEPA expects that a combination of ongoing and future activities under the Clean Air Act will achieve reductions in air deposition of mercury that will enable progress toward achievement of water quality standards.

Section 112 of the Clean Air Act and 40 CFR Parts 61 and 63 – maximum achievable control technology [MACT] Rules) will continue to ensure reductions in air emissions over the next decade. MACT standards require sources to meet specific emissions limits based on emissions levels already being achieved by many similar sources in the country. USEPA also applies a risk-based approach to assess how these technology-based emissions limits are reducing health and environmental risks. Based on this assessment, USEPA may implement additional standards to address any significant remaining, or residual, health or environmental risks (USEPA 2004a).

Under the Clean Air Act Amendments of 1990, the USEPA has issued stringent regulations to dramatically reduce and cap emission of air pollutants. Mercury emission nationwide were reduced by 45 percent by the year 1999 compared to 1990 mercury emissions http://www/epa.gov/air/mercuryrule/charts.html. The largest emitters of mercury to the atmosphere are coal-fired electric power plants. USEPA issued the Clean Air Mercury Rule on March 15, 2005 which establishes a market-based cap and trade program to cost effectively reduce mercury emissions from power plants. The rule caps mercury emissions at 38 tons in 2010 from a current 48 tons emitted and sets a second cap of 15 tons in 2018. The proposed rule includes two alternatives. The first alternative would require power plants to install MACT to achieve an estimated 30 percent reduction in mercury emissions by 2008. This will, when fully implemented, after 2020 reduce emissions of mercury from coal-fired power plants by 70 percent when fully implemented (http://www/epa.gov/air/mercuryrule/basic.html).

Municipal Waste Combustors (MWC): In 1995 USEPA issued emission limits for MMCs based on maximum achievable control technology. The implementation date for new and existing MWCs was December 2000. Overall mercury emissions from MWCs were estimated to be 54 tons per year (TPY) in 1990, and this regulation is expected to reduce mercury emissions from these types of facilities by at least 90 percent.

Medical and Waste Incinerator (MWI): In August 1997 USEPA issued emission limits for MWIs. The implementation date for new and existing MWIs was September 2002. Overall mercury emissions from MWIs are estimated to be reduced by 94 percent or more because of this regulation.

Hazardous Waste Combustors (HWC): In 1999 USEPA issued emissions standards for HWCs, including cement kilns and light weight aggregate kilns that burn hazardous waste. Overall mercury emissions from HWCs were estimated to be 2.5 percent of the total national mercury emissions in 1990. This regulation has not been implemented pending final resolution of a lawsuit. Once fully implemented, mercury emissions from HWCs are expected to be reduced by at least 50 percent.

Chlor-Alkali Plants: Late in 2003, USEPA issued a final regulation to reduce mercury emissions from chlorine production plants that rely on mercury cells. Today there are nine such plants in the United States although when the rule was begun there were 20. The regulation which requires a combination of controls for point sources such as vents, and management practices to address fugitive emissions will reduce mercury emissions from chlor-alkali plants by about 50 percent.

Industrial Boilers: In September 2004, USEPA issued a regulation to reduce emissions of mercury and other toxic air pollutants from industrial boilers that burn coal and/or other substances such as wood to produce steam. The steam is used to produce electricity, mechanical energy or to provide heat. These boilers are used at facilities such as refineries, chemical and manufacturing plants, and paper mills or they may stand alone to provide heat for shopping malls and university heating systems. It is expected that this rule will reduce mercury emissions by one third.

The benefit of the existing regulations has resulted in a decrease of both mercury deposition and mercury concentration in fish tissue in the Florida Everglades in the last 10 years. Mercury emissions in south Florida have declined from a high of 3,000 kilograms per year (kg/yr) in 1991 to 250 kg/yr in 2000, with a corresponding reduction in mercury deposition from a high in 1998 of 26 $\mu g/m^2$-yr to 17 $\mu g/m^2$-yr, and a corresponding decline in tissue concentrations of mercury in largemouth bass from 1.7 mg/kg in 1991 to 0.4 mg/kg in 2000 (USEPA 2003a).

8.2 MUNICIPAL AND INDUSTRIAL DISCHARGERS

These TMDLs focus on those facilities known to be discharging mercury or likely to be discharging mercury. Although every discharger has been assigned either an individual WLA or is covered by the group WLA, USEPA expects LDEQ to systematically identify any dischargers that are significant sources of mercury. USEPA will work with LDEQ to establish mechanisms for demonstrating that these loads are being met. Mechanisms that could be used to demonstrate compliance may include a certification process demonstrating that there are no known or suspected operations that could reasonably be expected to discharge mercury. Effluent sampling may be necessary for dischargers that cannot meet the certification requirement. Sampling requirements, if applicable, should include sampling and analyses using clean methods. USEPA Method 1631 is now available which has a detection limit of 0.0002 µg/L or 0.2 ng/L. In addition, USEPA Method 1669 should be used for sampling guidance. Mercury monitoring to meet the requirements of this TMDL should follow procedures as outlined in USEPA Method 1631. With these additional data, USEPA and LDEQ could consider the possibility of revising the TMDL at some point in the future if warranted.

If a facility is found to discharge mercury at levels above 12 ng/L, a mercury minimization plan may be required. USEPA expects that the State of Louisiana, as the duly authorized permitting authority, will determine any additional necessary elements of a mercury characterization/minimization plan, considering the size and nature of the affected facility. Local characteristics such as water velocity, bed substrate, oxygen content, and microbial community structure all contribute to methylation potential. Since these characteristics have not been defined for each of the dischargers in each subsegment, there exists the potential that effluent containing mercury may cause localized exceedances of the criteria and therefore, minimization plans and/or numeric limits may be necessary to assure that the discharge does not cause and/or contribute to an exceedance of the applicable WQS. In conclusion, due to uncertainty in the TMDL analysis, mercury minimization plans and/or numeric limits may be necessary to assure compliance with the WQSs. Based on the large number of NPDES dischargers in the study area, LDEQ should develop a prioritization strategy for determining the need for additional permit requirements within each coastal basin. Through these actions, over the long-term, it can be demonstrated that WLAs are being met.

8.3 POLLUTION PREVENTION

Source reduction, through product substitution and innovation, is the key element to pollution prevention. The U.S. industrial demand for mercury dropped 75 percent from 1988 to 1997 (http://www.epa.gov/mercury). Reductions in Hg use are driven by voluntary efforts and by increasingly strict federal and state regulations, such as increasing regulation of mercury in products or outright bans on the use of mercury in products for which alternatives are available. For example, in 1996 USEPA eliminated the use of mercury in most batteries under the Mercury Containing and Rechargeable Battery Management Act. Other voluntary measures such as the commitment by the American Hospital Association to reduce the use of mercury-containing products will continue to decrease the amount of Hg available in the waste stream. Next to source reduction, recycling is fundamental to Hg pollution prevention. When mercury must be used and recycling is not a possibility, proper disposal is critical to reducing the potential of dispersion to the environment.

8.4 LDEQ STATEWIDE MERCURY PROGRAM

The LDEQ has identified mercury as one of its priorities and is developing a mercury risk reduction plan to be finalized by the end of 2005. It is the intent of LDEQ to assess all sources of mercury to the environment in the state and to develop strategies to reduce public health risks associated with mercury. A series of public meetings were held with participation from various industry sectors and non-governmental organizations. In addition, meetings on risk communication have been and continue to be conducted for the purpose of enhancing public awareness relative to mercury and mercury exposure.

The approach of this initiative is intended to be exhaustive and comprehensive, looking at all sources of mercury with consideration given to methods of controlling releases to the environment. Potential action items include pollution prevention strategies, waste minimization, non-essential mercury-containing device phase-outs, recycling enhancements through rule development (such as Universal Waste Rule), remediation of known sites of mercury contamination, comprehensive approaches to locating and remediating legacy sites, rule development to minimize permitted mercury emissions and discharges, and enhanced public outreach to educate the public on efforts that can be conducted locally and within the home to enjoin the mercury reduction initiative. This approach used in the "Louisiana Mercury Risk Reduction Plan" will result in the greatest environmental benefit when applied on a regional and national scale. The LDEQ and USEPA will continue to develop this statewide mercury reduction strategy to its fullest potential, promoting and supporting its use in adjacent states and regions.

LDEQ continues its aggressive commitment to implementing a comprehensive statewide mercury program. The following excerpts from the recent LDEQ publication *Resource Guide to Understanding Mercury in Louisiana's Environment: 2003 Mercury Report* highlight some of the management strategies that will advance attainment of the reduction goals defined by these TMDLs (LDEQ 2003).

- Design and construction regulations for landfills to help ensure that mercury-laden materials do not leak from them.
- Historically, electrical switches in some natural gas meters contained mercury. Spills from these meters contaminated the ground and became sources of mercury to the environment. Since 1991, several natural gas pipeline companies with oversight from LDEQ, voluntarily cleaned the mercury from the environment around contaminated natural gas meter sites. To date, approximately 5,000 sites have been checked for mercury contamination and 2,500 that were contaminated have been cleaned.
- Recycling played a large part in not only reducing the amount of mercury used by industries, but also reducing the amount released to the environment. LDEQ's Recycling Section maintains a current list of all recyclers in the state, sorted by commodity.

Over the past 4 years LDEQ has worked to expand its statewide mercury monitoring program. The primary objective of this program was to determine statewide mercury contamination levels of fish commonly eaten in Louisiana, as well as mercury concentrations in sediments, water, and epiphytic plant material, and mercury loadings from aerial deposition.

Continued fish tissue data collection provides input for analyses of risks to human health due to consumption of mercury-contaminated fish. This allows LDHH and LDEQ to address public concerns regarding the safety of fish consumption from many waterbodies. Epiphytic plant material is used to help further define the significance of atmospheric sources of mercury. Results of the epiphytic plant material analyses, together with fish tissue, water and sediment concentration information, will continue to help address questions regarding sources of mercury. Additional local and statewide remedial actions can be more effectively targeted to reduce mercury sources by combining data generated from this and previous projects and the knowledge of LDEQ field personnel. This project will also provide baseline data that can be used for ongoing trend analysis.

LDEQ's sampling site selection continues to evolve and is based on several needs. New sites are sampled to expand the number of waterbodies tested. Recently, sites were selected in basin subsegments in which no previous sampling has occurred. Currently, nearly all waterbodies with fish populations sufficient to support human health risk assessment inputs have been sampled for mercury contamination. Waterbodies currently under an advisory for mercury are resampled annually. Some waterbodies are resampled if LDHH determines additional samples are needed to make a decision regarding fish consumption advisories.

Beginning in October 1998, LDEQ implemented an air monitoring program designed to assess the geographical extent and quantity of atmospheric mercury deposition. Air monitors currently exist at the Southeastern University Campus in Hammond, Louisiana; McNeese State University in Lake Charles, Louisiana; at the Louisiana State University in Chase, Louisiana, and in Alexandria, Louisiana in Rapides Parish. Samples are tested for wet deposition of total mercury during rainfall events. If rainfall occurs samples are collected weekly. LDEQ's air monitoring sites are part of the NADP and MDN. Weekly data from October 1998 through March 2004 are available. The data show mercury levels are being regularly detected in rainwater. The data are analyzed by NADP staff, and any future reports concerning deposition data will be published by the NADP. Any interested party may access the data at the following website: http://nadp.sws.uiuc.edu/mdn.

LDEQ adheres to well-defined sampling procedures when collecting mercury data. This program is an important tool for LDEQ in evaluating the progress of the mercury reductions prescribed by these TMDLs. LDEQ's targeted data collection efforts in subsegments with fish consumption advisories will provide the data necessary to ultimately remove the fish consumption advisory or revise the TMDL at some point in the future, if warranted.

SECTION 9
PUBLIC PARTICIPATION

When USEPA establishes a TMDL, 40 C.F.R. Section 130.7(d)(2) requires USEPA to public a public notice and seek comments concerning the TMDL. USEPA prepared this TMDL pursuant to the consent decree, Sierra Club, *et al.* v. Clifford, *et al.*, No. 96-0527, (E.D. La.) signed and entered April 1, 2002. Federal regulations require that public notice be provided through the Federal Register and through newspapers in the local area.

These draft TMDLs were originally published in the Federal Register on December 9, 2004 (Volume 69, Number 236, page 71409). Several entities submitted comments and requested an extension of the comment period. USEPA decided to reissue revised draft TMDLs to address the original comments and to provide an additional public comment period. The revised draft TMDLs were published in the Federal Register on April 14, 2005 (Volume 70, Number 71, page 19760). These TMDLs were also noticed in local newspapers. Comments and additional information were submitted during the 30-day public comment period and these TMDLs have been revised accordingly.

Comments and responses are found in Appendix H. The original text of the comments can also be found in a file named CommentsHgTMDLsJune2005.pdf at http://www.epa.gov/region6/water/tmdldrafts.htm. USEPA will provide notice to LDEQ that these TMDLs have been made final. USEPA will also request LDEQ to incorporate these TMDLs into the state Water Quality Management Plan.

SECTION 10
REFERENCES

Ache, B.W., Boyle, J.D., and Morse, C.E. 2000. A Survey of the Occurrence of Mercury in the Fishery Resources of the Gulf of Mexico. Prepared by Battelle for the U.S. EPA Gulf of Mexico Program, Stennis Space Center, MS. January 2000.

AMSA 2002. *Mercury Source Control and Pollution Prevention Program Evaluation-Final Report.*

Benoit, J., C. Gilmour, A. Heyes, R.P. Mason, C. Miller (2003). Geochemical and Biological Controls Over Methylmercury Production and Degradation in Aquatic Ecosystems. In: Biogeochemistry of Environmentally Important Trace Elements, ACS Symposium Series #835, Y. Chai and O.C. Braids, Eds. American Chemical Society, Washington, DC. pp. 262-297.

Cossa, D., M. Coquery, C. Gobeil, and J. Martin. 1996. Mercury Fluxes at the Ocean Margins. In: Global and Regional Mercury Cycles: Sources, Fluxes and Mass Balances. Edited by: W. Baeyens, R. Ebinghaus, and O. Vasiliev. Kluwer Academic Publishers, Netherlands. Pp 229-248.

Fitzgerald, W. F. And R. P. Mason (1996). The global mercury cycle: Oceanic and anthropogenic aspects *In: Regional and Global Mercury cycles: Sources, Fluxes, and Mass Balances*, edited by W. Baeyens, O Vasiliev, and R. Ebinghaus), pp. 85-108. Kluwer Academic Publishers, the Netherlands.

Gill, G. A., N. S. Bloom, S. Cappellino, C. T. Driscoll, C. Dobbs, L. McShea, R. Mason, and J. Rudd (1999). Sediment-Water Fluxes of Mercury in Lavaca Bay, Texas. *Environmental Science and Technology*, **33**: 663-669.

Gilmour, C. C., G. S. Riedel, M. C. Ederington, J. T. Bell, J. M. Benoit, G. A. Gill, and M. C. Stordal (1998). Methylmercury concentrations and production rates across a trophic gradient in the northern Everglades. *Biogeochemistry*, **40**: 327-345

Gordon, M.L. Undated. A preliminary report: An investigation of atmospheric mercury as possible sources for contamination of North Louisiana's lakes. Louisiana Department of Environmental Quality, Air Quality Division. Baton Rouge, LA. 14pp.

Guentzel, J. L., W. M. Landing, G. A. Gill and C. D. Pollman (2001). Processes influencing rainfall deposition of mercury in Florida: The FAMS Project (1992-1996). *Environmental Science and Technology,* **35**: 863-873.

Krabbenhoft, D.P. and D.A. Rickert. 1995. Mercury contamination of aquatic ecosystems. U.S. Geological Survey. Internet article. http://h2o.usgs.gov/public/wid

Lamborg, C. H., W.F. Fitzgerald, J. O'Donnell, and T. Torgeson (2002). A non-steady state compartmental model of global-scale mercury biogeochemistry with interhemispheric atmospheric gradients. *Geochimica et Cosmochimica Acta*, **66**: 1105-1118.

LDEQ 1991. Quality assurance project plan surface water monitoring and analysis. Office of Water Resources, Baton Rouge, LA.

LDEQ 2000. 2000 Mercury Report.

http://www.deq.state.la.us/surveillance/mercury/2000report/intro.htm

LDEQ 2000a. Printed from LDEQ website.

http://www.deq.louisiana.gov/surveillance/mercury/mercsumm.htm#glossary

LDEQ 2003. Resource Guide to Understanding Mercury in Louisiana's Environment, 2003 Annual Mercury Report.

LDEQ 2004. State of Louisiana Water Quality Management Plan Water Quality Inventory Integrated Report (Section 305(b) and 303(d) Reports).

LDEQ 2004a. "Taking the Mercury Initiative". Louisiana Department of Environmental Quality Seminar to Discuss Mercury in Louisiana. Baton Rouge, LA. September 13, 2004.

LDEQ 2004b. Environmental Regulatory Code: Part IX. "Water Quality Regulations". Baton Rouge, LA: Office of Water Resources, Water Quality Management Division.

LDEQ 2004c. LDEQ Fish Consumption and Swimming Advisories.

http://www.deq.louisiana.gov/surveillance/mercury/fishadvi.htm

Lindberg, S. E. and W. J. Stratton (1998). Atmospheric mercury speciation: Concentrations and behavior of reactive gaseous mercury in ambient air. *Environmental Science and Technology*, 32: 49-57.

Louisiana's CWRPPA Basins 2004. Printed from http://www.lacoast.gov/geography/index.htm

Marvin-Dipasquale, Mark, J. Agee, C. McGowan, R.S. Oremland, M. Thomas, D. Krabbenhoft, and C.C. Gilmour (2000). Methylmercury degredation pathways: A comparison among three mercury impacted systems. *Environmental Science and Technology,* **34**: 4908-4916.

Mason, R. P., N.M. Lawson, A.L. Lawrence, J.J. Leaner, J. G. Lee, and G-R. Sheu (1999). Mercury in Chesapeake Bay. Marine Chemistry, 65: 77-96.

Montagna, Paul A. and Harper, Donald E. 1996. "Benthic Infaunal Long-Term Response to Offshore Production Platforms in the Gulf of Mexico". Can. J. Fish. Aquat. Sci. 53:2567-2588.

National Atmospheric Deposition Program Mercury Deposition Network

(http://nadp.sws.uiuc.edu), 2004.

Neff, J.D. 2002. Fates and Effects of Mercury from Oil and Gas Exploration and Production Operations in the Marine Environment. American Petroleum Institute.

NOAA/NIMFS/Office of Science and Technology/Fisheries Statistics and Economics Division website (http://www.st.nmfs.gov/st1/recreational/index.html accessed in August 1999)

Nriagu, J. O. (1989). A global assessment of natural sources of atmospheric trace metals. *Nature*, **338**: 47-49.

Rabalais, N.N., W.J. Wiesman Jr., and R.E. Turner. 1997. Comparison of continuous records of near-bottom dissolved oxygen from the hypoxic zone along the Louisiana coast. Estuaries Vol. 17 No. 4.

Stordal, M. C., G. A. Gill, L. S. Wen, and P. H. Santschi (1996). Mercury phase speciation in surface waters of three Texas estuaries: the importance of colloidal forms. *Limnology and Oceanography*, **41**:52-61.

Texas A&M University, Laboratory for Oceanographic and Environmental Research 2004. Printed from website http://loer.tamug.tamu.edu/Research/Mercury/mercury.htm

Trefry, John H., et al. 2003. "Concentration of Total Mercury and Methylmercury in Sediment Adjacent to Offshore Drilling Sites". Society of Petroleum Engineers. March 2003.

Trefry, John H. and Smith, J.P. 2003a. "Forms of Mercury in Drilling Fluid Barite and Their Fate in the Marine Environment: A Review and Synthesis" Society of Petroleum Engineers. March 2003.

Trudel, M. and J.B. Rasmussen. 1997. Modeling the elimination of mercury in fish. Env. Sci.Technol. 31: 1716-1722.

Ullrich, S. M., T. W. Tanton and S. A. Abdrashitova (2001). Mercury in the Aquatic Environment: A Review of Factors Affecting Methylation**,** *Critical Reviews in Environmental Science and Technology,* **31**: 241-293.

United States 2002. Sierra Club and Louisiana Environmental Action Network versus Gregg Cooke, Christine Whitman, and USEPA. Consent Decree (Civil Action No. 96-0527 Section: "S" 4, April 2002.

USEPA 1995. National Forum on Mercury in Fish, Conference Proceedings. Environmental Protection Agency, Office of Water, USEPA 823-R-95-002. June 1995.

USEPA 1996. "Evaluation of the Presence of Priority Pollutants in the Discharges of Minor POTWs". June 1996. http://www.epa.gov/owm

USEPA 1997. Mercury Study Report to Congress. U.S. Environmental Protection Agency, Office of Air Quality and Standards and Office of Research and Development, USEPA 452/R-97-003. December. 1997.

USEPA 2001. Water Quality Criterion for the Protection of Human Health: Methylmercury. USEPA, Office of Science and Technology, Office of Water, January 2001 (USEPA-823-R-01-001).

USEPA 2001a. Better Assessment Science Integrating Point and Nonpoint Sources, BASINS, Version 3.0, U.S. Environmental Protection Agency, Office of Water, Washington, DC.

USEPA 2002. TMDL for Mercury in Fish Tissue for Coastal Waters of the Calcasieu River Basin, May 2002.

USEPA 2002a. TMDLs for Segments Listed for Mercury In Fish Tissue for the Ouachita River Basin, and Bayou Bartholomew Arkansas and Louisiana to Columbia. USEPA, Region 6, Watershed Management Section, March 22, 2002.

USEPA 2002b. Total Maximum Daily Load for Toxics for the Calcasieu Estuary, May 2002.

USEPA 2003. Mercury TMDLs for Little River and Catahoula Lake Watershed. USEPA, Region 6, Watershed Management Section, February 2003.

USEPA 2003a. Integrating Atmospheric Mercury Deposition and Aquatic Cycling in the Florida Everglades – An Approach for Conducting a Total Maximum Daily Load Analysis for an Atmospherically Derived Pollutant. Florida Department of Environmental Protection, November 2003.

USEPA 2004. *REMSAD Air Deposition Modeling in Support of TMDL Development for Southern Louisiana.* Prepared by ICF Consulting for USEPA Region 6. August 5, 2004.

USEPA 2004a. Printed from USEPA Website http://www.epa.gov/air/oaqps/takingtoxics/p1.html#2.

USEPA 2004b. Total Maximum Daily Load (TMDL) Development for Total Mercury Fish Tissue in the Canochee River (Canochee) Watershed, August 2004.

U.S. Bureau of the Census 2002. *Median Population by Counties of the United States, 2002*. Prepared by the Geography Division, Bureau of the Census. Washington, DC, 2002.

Waldon, Michael G., Ph.D., "Louisiana Total Maximum Daily Load Technical Procedures, 1994," CLIWS-WQR 91.10. March, 2000 (revised). Center of Louisiana Inland Water Studies (CLIWS), Department of Civil Engineering, University of Southwestern Louisiana, for the LA Department of Environmental Quality, Office of Water Resources, Water Pollution Control Division, Engineering Section.

Wiener, J. G., D. P. Krabbenhoft, G. H. Heinz, and A. M. Scheuhammer (2003). Ecotoxicology of Mercury. In: Handbook of Ecotoxicology, second edition. Edited by: D. J. Hoffman, B. A. Rattner, G. A. Burton, jr., and J. Cairns, jr. Lewis Publishers, a CRC Press Company, Boca Raton, FL, pp. 409-463.